DOCUMENT RESUME

ED 186 769 CE 025 430

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TITLE Biomedical Equipment Technology: A Curriculum Planning Resource Guide.
INSTITUTION Conserva, Inc., Raleigh, N.C.
SPONS AGENCY Illinois State Office of Education, Springfield. Div. of Adult Vocational and Technical Education.
PUB DATE Jan 80
CONTRACT R-35-30-X-0222-206
NOTE 69p.; For related documents see CE 025 423-429.

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Advisory Committees; *Allied Health Occupations Education; Annotated Bibliographies; Associate Degrees; *Biomedical Equipment; *Curriculum; *Curriculum Development; Educational Certificates; Educational Equipment; Educational Facilities; Electronics; Employment Qualifications; Equipment Evaluation; Equipment Maintenance; Labor Needs; *Medical Laboratory Assistants; Occupational Information; Postsecondary Education; *Program Development; Resource Materials; Teacher Qualifications; Vocational Education
IDENTIFIERS Emerging Occupations; Illinois

ABSTRACT

This curriculum resource guide, one of seven developed by the State of Illinois to present information on new and emerging curricula existing in the nation, can be used as a basis for local educators to determine the resources needed to offer biomedical equipment technician curricula and to initiate curriculum development at the local level. Chapters 1 and 2 contain an introduction and procedures for using the guide. Chapter 3 describes the job duties and typical employers of biomedical equipment technicians. In chapter 4 alternative curriculum approaches are presented--an associate degree program, certificate program, and electronics option. Chapter 5 discusses these resources required to implement the program: curriculum advisory committee, facilities and equipment, and instructor qualifications. The final chapter contains thirty-nine abstracts of curriculum and instructional materials; information provided includes title, author(s), availability, and price. Appendixes include lists of schools offering coursework in biomedical equipment technology and related agencies/organizations and journals/periodicals, task listings and job competencies, certification of biomedical equipment technicians, and equipment lists and inventories. (A report on the project that identified the seven new and emerging occupations is available as CE 025 423. See Note for other curriculum resource guides in ERIC.) (YLB)

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# BIOMEDICAL EQUIPMENT TECHNOLOGY: A CURRICULUM PLANNING AND RESOURCE GUIDE

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Sponsored by:

Illinois State Board of Education
Donald F. Muirheid, Chairman
Joseph M. Cronin,
State Superintendent of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

January, 1980

This Research Report was developed pursuant to Contract # R-35-30-X-0222-206 with the Illinois State Board of Education, Department of Adult, Vocational and Technical Education, Research and Development Section. Directors undertaking projects under such sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated, however, do not necessarily represent official Illinois State Board of Education opinions or policy.

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

# PREFACE

In 1978 CONSERVA, Inc. was awarded a contract by the Illinois Department of Adult, Vocational, and Technical Education (DAVTE) to identify new and emerging occupations within the State and to determine the types, levels, and distribution of new vocational education curricula which are needed to meet the employment demands for skilled workers in those occupations. To accomplish the objectives of the project, CONSERVA staff undertook a search for potential new occupations through a review of similar national research efforts, recently enacted Illinois legislation, and technical and trade journals. Telephone contacts to identify new and emerging occupations were made with over 450 individuals nationwide, representing industries, educational institutions, professional and trade associations, government agencies, labor unions, service organizations, and private employers.

Through these cumulative efforts, seven occupations were identified which met pre-determined criteria defining new and emerging occupations, i.e., 1) the occupation has come into existence within the past decade; 2) the occupation is skilled or technical in nature, requiring at least six months of vocational education preparation but less than a four-year college program; 3) there are no or limited vocational education programs within Illinois which are preparing students to enter the occupation; and 4) information is currently available which reflects an anticipated shortage of workers within the State over the next five years. The seven identified new and emerging occupations are:

- Biomedical equipment technician
- Industrial hygiene technician
- Podiatric assistant
- Therapeutic recreation technician
- Swine confinement facility assistant manager
- Solar energy technician
- Halfway house manager

In order to hasten the inauguration of curricula for these new and emerging occupational areas, the Illinois Department of Adult, Vocational and Technical Education (DAVTE) awarded a second contract to CONSERVA. The purpose of that project was to locate new and emerging curricula that are currently in existence in the nation, to obtain available curriculum documentation for each of the seven occupational areas and to incorporate that information into seven curriculum resource guides. This volume represents one of the products of that effort, a curriculum resource guide which can be used as a basis for initiating a curriculum for preparing Biomedical Equipment Technicians.

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# I. INTRODUCTION

Biomedical Equipment Technicians (BMETs) are employed by hospitals, equipment manufacturers, and sales and distribution firms primarily to test, maintain and service biomedical equipment. Historically, these functions have been served by such professions as the electronics technician, medical equipment repairer or the electronic medical technician for as long as hospitals have utilized electronic equipment. It is only within the last ten years, however, with increased sophistication of instrumentation and stringent Joint Commission on Accreditation of Hospitals safety compliance regulations, that the BMET has emerged as a distinct and urgently needed occupation.

Within Illinois the demand for BMETs, particularly in urban areas, is acute. It was estimated recently that the five-year demand for BMETs is 286 statewide, with a majority of the positions located in the Chicago area (Spetz, et al., 1978). Furthermore, a survey conducted by Oakton Community College in 1978 revealed that two to three programs in BMET were needed to satisfy the needs of Northeast Cook County alone. Despite this documented pressing need, there are currently few curricula in Illinois which prepare students to become employed as BMETs.

This curriculum planning and resource guide was prepared to serve as a basis for local educators to determine the resources needed to offer BMET curricula and to initiate curriculum development at the local level. The difficulties and expense of developing curricula for a relatively new occupation such as BMET are well documented (Meleen, et al., 1976; Nelson, 1978; Spetz, et al., 1978; Forgione & Kopp, 1979). This guide is intended to facilitate BMET curriculum development in Illinois by taking full advantage of related curriculum development efforts of institutions across the nation.

Essentially, the curriculum planning and resource guide is a synthesis of curriculum materials currently being used to offer training in biomedical equipment technology. It consists of a description of job duties and competencies, suggested curriculum options, program resource requirements, abstracts of curricular materials and appendices listing further sources of information. Information presented in the guide was obtained from existing curricula in BMET (see Appendix A), which were identified through extensive contacts with State vocational eucation agencies, professional and trade associations and directories, and local institution offering BMET curricula. In most instances, representatives of BMET curricula graciously provided CONSERVA with documentation of availabie curriculum materials and offered assistance in identifying instructional materials, resource requirements and other useful information. Contacts made with educational publishers, biomedical equipment manufacturers and producers of audio-visual instructional materials helped to identify and procure textbooks and other learning materials available for providing instruction in BMET.

Suggested procedures for using the curriculum planning and resource guide are presented in the next chapter, which describes a five-step curriculum development process keyed to the contents of this guide. This is followed by chapters describing BMET job duties, alternative curriculum approaches and program resource requirements. The final chapter presents abstracts of available curriculum and instructional resources.

# II. PROCEDURES FOR USE

Presented in this chapter are procedures for using this guide as a resource in the planning, organization and development of a curriculum in biomedical equipment technology. The approach advocates the reliance on existing BMET curricula which have been developed by other institutions. Though it is seldom practical or feasible for an institution to adopt an existing curriculum in its entirety, the work of others does offer a solid foundation upon which to base planning and development activities. The steps outlined below illustrate how the materials presented and referenced in this guide can be utilized in initiating a curriculum for biomedical equipment technology, an occupation which has been determined new and emerging in Illinois, yet one for which there are established curricula in other parts of the country.

The curriculum development process is summarized in Table 1, accompanied by a rationale for each of the procedural steps and references to relevant sections of the resource guide. The procedures elaborated upon below assume experience in curriculum development on the part of the reader. Steps which are well-known to those with such experience are briefly outlined and tied in to relevant information presented in this guide. In those instances where traditional curriculum development procedures are not appropriate due to the newness of the occupation, further elaboration is provided.

**Table 1.**
**Curriculum Planning and Development for New and Emerging Occupations**

| Step | Purpose | Reference |
|---|---|---|
| 1. Determine area or regional employment opportunities and extent of student interest | To justify offering the program | Figure 1<br>Chapter III |
| 2. Establish curriculum advisory committee | To obtain advice on the structure and content of the curriculum and the methodology to be utilized in instruction | Chapter V<br>Appendices B, C |
| 3. Verify, modify, and refine job competencies and/or duties | To align general duties with specific local employment requirements | Chapter III<br>Appendices D, E |
| 4. Assess resource requirements | To determine institutional capability to offer the program | Chapter V<br>Appendix G |
| 5. Develop curriculum | To align resources with job competencies and student interests and qualifications | Chapters IV, V, VI<br>Appendices F, H, I |

### Step 1. Determine Area or Regional Employment Opportunities and Student Interest

The first step in planning a curriculum for biomedical equipment technology is to determine the demand, in terms of employment opportunities and student interest, for offering training in the occupational area. Five-year projections of regional demand for BMETs have been estimated using data on hospital size and projections produced by the Governor's Office of Manpower and Human Development (Spetz, et al., 1978). These projections, which are portrayed in Figure 1, can serve as a preliminary estimate of employment demand. However, since the estimates are based on secondary sources of regional employment demand,they are subject to local fluctuations. Thus, if the regional estimates indicate a potential need for a program in BMET, a more in-depth investigation of the demand should be undertaken. This will first involve conferring with other post secondary and/or proprietary schools in the region to determine whether any of those institutions are planning to respond to the need by developing similar curricula. Findings from such conferences could result in the need for joint developmental efforts or a determination that only one operating curiculum is necessary to meet the regional demand. In the latter case a joint decision between the institutions and the appropriate State agency as to the most qualified and/or cost-efficient institutions(s) to offer training should be sought.

The next step is to refine the preliminary demand estimates through a survey of the potential employment community. Job duties and typical employers of BMETs are listed in Chapter III of this report. That information may be used as a basis for the development of survey instrumentation and selection of a sample of employers. It will be necessary to include a BMET job description in the instrumentation. This will ensure that employers are responding to similar positions even if the position is not referred to as a BMET. Additionally, employers should be requested to list any discrepancies in the job description as compared to the duties of their BMET employees. Contacts made with employers during the survey process should further serve to reveal additional places of employment of BMETs, to identify potential curriculum advisory committee members and/or participants in a cooperative vocational education program and to stimulate community interest.

The other component of demand which is necessary to estimate prior to curriculum development is student interest in, and qualifications for, the BMET curriculum. This is especially important for ensuring sufficient enrollment when large expenditures, particularly for equipment purchases and instructional costs, are anticipated. The information on job duties (Chapter III) and typical curriculum and course requirements (Chapter IV) can help to determine potential student interest in enrolling in a BMET curriculum. Summaries of that information can be provided to career information or guidance centers and secondary school guidance counselors in the service area to obtain estimates of potential student interest.

When the necessary information on students' interests is not directly available from the career information centers or

**Figure 1.**
**1978-1983 Regional Employment Requirements for Biomedical Equipment Technician**
**(Statewide Total = 431)**

guidance counselors, it may be desirable to conduct a survey of potential students. The sample could include students enrolled at the institutions, secondary students enrolled in both public and private institutions, and selected out of school populations such as persons employed in the related field of electronics technology. Again, the information on job duties and curriculum and course requirements contained in Chapters III and IV can be summarized in the survey instrument. The results of the survey will not only provide information on student demand but also indicate the types of students the curriculum is most likely to attract—information that later will be useful in designing a curriculum. If the decision is made to offer the curriculum, these potential BMET students should be made aware of its availability.

### Step 2. Establish Curriculum Advisory Committee

The second stage of the development process, provided that sufficient demand exists for the curriculum, is to establish a curriculum advisory committee. Since the committee will be heavily involved in subsequent steps in the curriculum development process, it is imperative that in the selection of members adequate consideration be given to individuals' qualifications in light of the responsibilities of the committee. Potential members of a BMET curriculum advisory committee are presented in Chapter V. Additionally, the institution may wish to include outside consultants on the advisory committee if insufficient local expertise exists. Since biomedical equipment technology is a relatively new field, it may be essential to solicit external, up-to-date information. This may be obtained from relevant agencies and organizations, in addition to consultants. Lists of potential consultants for developing a BMET curriculum and relevant groups are presented in Appendices B and C, respectively.

At the first meeting of the advisory committee, it is suggested that procedures for the operation of the committee, extent of authority, principal objectives and time schedules be established. Subsequent responsibilities of the committee will be to ensure that the curriculum is consistent with employer requirements and to facilitate placement of students.

### Step 3. Verify, Modify and Refine Occupational Competencies and/or Duties

The derivation of job competencies can be a time-consuming and difficult task, particularly for new and emerging occupations. An alternative is to verify and refine existing competencies and/or task listings. Various lists of occupational competencies and tasks of the BMET, which supplement job duties described in Chapter III, are presented in Appendix D. These should be reviewed and refined to reflect unique and general employment requirements of the institution's service area. Input from the curriculum advisory committee and/or employers surveyed in Step 1 will facilitate the accomplishment of this process.

Employer input may be obtained concurrently with the survey conducted in Step 1 by appending a list of tasks or competencies to the survey questionnaire. Employers are requested to rate tasks, manipulative and communication skills, and technical knowledges as to their relevance to the occupation. For example, a five-point rating scale could be applied to a list of skills.[1]

5 - The skill is essential
4 - The skill is very important
3 - The skill is desirable
2 - The skill is not important
1 - The skill is not applicable

A similar scale could be applied to the rating of tasks and technical knowledges. Employers should also be given the opportunity to add to or modify the presented skills, tasks, and technical knowledges. Based on the employer ratings and similar input from curriculum advisory committee members, job competencies can be refined to reflect the needs of the service area. These refined competencies should then be used in defining segments of a BMET curriculum.

### Step 4. Assess Resource Requirements

In order to determine the capability of an educational institution to offer the curriculum, it is necessary to assess the capabilities of the instructional staff, facilities and available equipment to provide students with the needed manipulative

[1] From Johnson County (Kansas) Community College, Office of Institutional Research. "Employer Manpower Needs and Job Entry Requirements for Biomedical Equipment Technician."

skills, technical knowledge and communication skills. The available resources will have a definite impact on the structure of the curriculum developed in the next step. For example, if equipment necessary for teaching laboratory skills is not available, a cooperative program may be considered.

The types of equipment, facilities and instructors necessary for implementing a BMET curriculum are presented in Chapter V. With the assistance of the curriculum advisory committee, suggested resources should be evaluated in light of the refinements in job competencies made in Step 3. Additions or changes to resource requirements may be necessary to align them with unique area or regional employment requirements. The resources of the institution should then be assessed as to whether they are adequate to meet the requirements of a BMET curriculum. Where resources are lacking, outside assistance could be solicited; e.g., equipment contributions from hospitals or manufacturing firms, supplementary guest lectures, equipment demonstrations by suppliers or field trips. Cooperative arrangements with BMET employers, consisting of on-site learning opportunities for students, could also serve to lessen the burdens of expenditures for equipment and instructional resources.

**Step. 5. Develop Curriculum**

At this point, it will be appropriate to determine the curriculum objectives and course progression, instructional materials, and methods and modes of instruction to be used in teaching students the necessary competencies to function as biomedical equipment technicians. Curriculum advisory committee input is most important during this phase of the curriculum planning process. Suggested BMET curriculum options, which are based on curricula currently in use in institutions across the nation, are presented in Chapter IV. Dependent on institutional resources, area or regional competency requirements, and anticipated student interests and qualifications, one or a combination of the curriculum options may be selected. Curriculum and coursework content may then be modified or expanded to address curriculum objectives and unique service area and institutional requirements. Other curriculum guides and materials obtained from existing programs are abstracted in Chapter VI. These guides and materials may be of further use in determining the appropriate curriculum and will be available for local review from the East Central Curriculum Coordination Center in Springfield.

Once the curriculum has been outlined and course objectives established, appropriate instructional materials for achieving the objectives will need to be identified. This process can be facilitated by reviewing the abstracts of instructional materials presented in Chapter VI. The abstracts should be reviewed with the following considerations in mind:

- Relationship of the material to course objectives
- Consistency of the material with mode and methods of instruction
- Compatability of the material with students' anticipated levels of achievement
- Effectiveness of the material in presenting information
- Cost-effectiveness of the material

Selection of materials for instruction should of course be preceded by a critical review of the actual documents, audio-visual, materials, etc.; however, alternatives may be narrowed down by examining abstracts contained in Chapter VI. A majority of the materials abstracted have been procured and will be made available by DAVTE to local educators for further review, preview and assessment of learning possibilities.

The steps outlined in the foregoing discussion represent an approach to curriculum development that relies heavily on the developmental efforts of others. However, it is not suggested that an existing curriculum be adopted in whole without giving due consideration to the transferability of such components as regional employer requirements, student needs, and resource and institutional requirements. The value of a curriculum advisory committee in addressing these considerations has been stressed throughout the curriculum development process. If the recommended steps are taken in the planning and development of the curriculum, the guide may serve to eliminate duplication of effort and as such can represent a cost-effective approach to curriculum development.

# III. JOB DESCRIPTION

This chapter describes the job duties and typical employers of BMETs. The information is intended for use during two steps of the curriculum planning process. First, it can serve as a guide when contacting employers and students to determine employment opportunities for BMETs and student interest in enrolling in a BMET curriculum. Secondly, the general information on job duties and the specific competencies presented in Appendix D can be reviewed, modified and refined by employers and advisory committee members so as to ensure that the curriculum will be responsive to the specific BMET occupational skills needed in the service area.

The biomedical equipment technician (BMET), as defined by the Association for the Advancement of Medical Instrumentation, is:

> An individual who is knowledgeable about the theory of operation, the underlying physiological principles and the practical, safe clinical applications of biomedical equipment. His [her] capabilities may include installation, calibration, inspection, preventive maintenance, and repair of general biomedical and related technical equipment, as well as operation or supervision of equipment control, safety and maintenance programs or systems. (Altman, 1977)

Specific duties performed by a BMET vary substantially dependent upon the type of employer and also upon the size and organizational structure of the place of employment. Primary employers of BMETs are hospitals, manufacturing firms and sales and distribution firms. BMETs also may be employed by contract maintenance firms, medical research organizations or government agencies. Duties within the primary employment settings are outlined below. Additionally, job tasks and competencies which have been developed for the position are presented in Appendix D.

**Hospitals**

The greatest diversity in duties performed by the BMETs occurs in the hospital setting where the BMET may be responsible for all of the functions outlined above. BMETs working in a hospital setting may be involved in the installation of biomedical equipment. This could include advising hospital personnel on the purchase of equipment; performing pre-purchase tests for accuracy, performance, maintainability and quality of construction; adapting equipment to meet specific performance requirements; incorporating equipment into present hospital systems; and instructing personnel in how to operate the equipment. In testing, troubleshooting and repairing equipment, the BMET uses oscilloscopes, multimeters, signal generators, power supplies and hand and power tools. Duties include setting up and operating test equipment, reading and interpreting schematics and wiring diagrams, cleaning equipment, assuring equipment safety, checking the adequacy of power and replacing faulty parts such as transistors, integrated circuits and capacitors. Additionally, the BMET adjusts and calibrates styli, oscillographs and other recording instruments. Detailed records of equipment maintenance and repair procedures are kept by the BMET.

Because of the diversity and changing nature of biomedical equipment, part of the BMET's job is to keep abreast of technological advances in the field. Generally, the BMET is responsible for reviewing journals, codes and standards, sales and service manuals, parts catalogs and other relevant literature.

The duties outlined above do vary somewhat dependent on the size of the hospital. Larger hospitals may employ a team of BMETs, allowing for increased specialization within the hospital (e.g., in surgical, intensive care and coronary care units) or by technical area (e.g., electo-mechanics, hydraulics and pneumatics). In these settings a BMET may function administratively in such activities as supervising other employees, documenting services and scheduling demonstrations and equipment tests. A small institution, on the other hand, may require only one BMET to be responsible for all electro-medical equipment in the hospital. In this case, the position would result in more diversity in problems encountered and consequently more frequent interactions with service personnel.

**Manufacturing Firms**

In the manufacturing setting, BMETs are likely to encounter the more difficult equipment problems. In addition to equipment adjustment, assembly, calibration and repair, duties performed by BMETs in manufacturing may include sales support (service), conducting training seminars under factory sponsorship and interaction with laypersons. BMETs may also participate in equipment design, producing prototypes, assembling factory units and preparing service manuals.

**Sales and Distribution Firms**

BMETs who are employed by equipment distributors primarily function in a sales/service capacity, with similar but less varied duties as the hospital technicians since they often deal with specialized products. Dependent upon the degree of specialization of the equipment and the number of pieces of equipment in operation in the field, the BMET position in a distributor setting may require considerable expertise in equipment servicing, analysis of malfunction, on-site repair/adjustment and instructions to users in the most effective utilization of equipment.

**Certification**

The Board of Examiners for Biomedical Equipment Technicians, Association for the Advancement of Medical Instrumentation, offers a certification examination for BMETs. One of the following criteria must be met prior to taking the certification examination:

1) Two years' BMET experience and an associate degree in BMET,
2) Four years' BMET experience, or
3) Three years' BMET experience and an associate degree in electronics.

Further information regarding certification procedures is presented in Appendix E.

# IV. CURRICULUM APPROACHES

This chapter provides information on the structure of BMET curricula and the content of specific courses designed to provide students with the various skills and technical knowledges necessary for employment as biomedical equipment technicians. The curriculum structure and content reflect alternative approaches for BMET preparation. Each alternative is presented for consideration in light of institutional resources and service area needs; they are intended to serve as a framework which can guide in developing BMET curricula within Illinois.

A number of approaches have been employed by community colleges and technical institutes to educate biomedical equipment technicians. The length and content of alternative curricula vary, dependent on student interests and need as well as area or regional labor market characteristics and employer needs. Typically, one or more of three approaches may be used for providing preparation in biomedical equipment technology:

- Associate Degree Program
- Certificate Program
- Electronics Curriculum: BMET Option

Associate degree programs generally require two years of coursework to complete. In addition to courses in biomedical equipment technology, classroom and laboratory study is provided in electronics, applied science, medical terminology, anatomy and physiology, and general education courses required for graduation. A practicum, at a cooperating hospital or manufacturer, frequently is required.

Certificate programs consist of less coursework than the associate degree programs and generally can be completed in one year. The curriculum may provide only technical portions of the two-year program or may prepare students to enter employment at a lower level of proficiency by providing a broad introduction to the field.

An option within an associate degree electronics curriculum provides electronics technicians with some specialization in biomedical equipment technology. Students may choose to specialize during their second year of education by selecting BMET courses as part of their programs of study. Alternatively, the specialization may require an extra quarter or semester of BMET coursework/internship by students who have completed a regular electronics curriculum.

The following sections of this chapter describe in greater detail the three approaches outlined above. Suggested curricula, which were derived from a review of curricula in existence nationwide, are presented for each alternative approach. Additionally, a supplementary document[1]—consisting of curriculum outlines, course descriptions and course syllabi obtained from a variety of sources—is available for review from the East Central Curriculum Coordination Center in Springfield.

## ASSOCIATE DEGREE PROGRAM

A common approach used by community colleges and technical institutes in preparing students for employment as biomedical equipment technicians is to offer a two-year program of coursework and clinical experience leading to an associate degree. Since the specialized functions performed by a practicing BMET are often critical in terms of patient and employee safety, two years of education is needed to provide the entry level competencies required in hospital, manufacturing or service employment settings. Coursework within the BMET curriculum is usually supplemented with an internship at a hospital or manufacturing firm during one or two summer sessions or through more intensive cooperative work experience. Work experience, even on a limited basis, is considered an essential component of an associate degree curriculum.

The two-year curriculum suggested below is based on a review and comparison of BMET associate degree curricula currently in operation. The curriculum resulting from that review closely approximates that suggested by the Education Committee of the Society of Biomedical Equipment Technicians (see Appendix F). It is designed to prepare entry-level BMETs who will be capable, under supervision, of installing, calibrating, inspecting, performing preventive maintenance of, and repairing biomedical equipment. With additional experience acquired as an employee, the graduate of the program will have the opportunity to assume added responsibilities and more complex duties. Dependent on institutional resources and requirements for the associate degree, modifications in the suggested base curriculum may be required. Additionally, based on information obtained through earlier program development steps (e.g., determining employment demand and refining job competencies), the suggested curriculum can be adapted to suit area or regional needs and characteristics.

| *Biomedical Electronics Courses* | Semester Credit Hours |
|---|---|
| Introduction to Biomedical Equipment Technology | 3 |
| Hospital Safety, Ethics and the Law | 2 |
| Biomedical Instrumentation | 4 |
| Advanced Biomedical Instrumentation | 4 |
| Biomedical Systems | 4 |
| Practicum | 4 |
| *Related Science and Technical Courses* | |
| Technical Mathematics I | 3 |
| Technical Mathematics II | 3 |
| Applied Science (Technical Physics and Chemistry) | 4-6 |
| Anatomy and Physiology | 3 |
| Shop Techniques | 2 |
| DC and AC Circuits | 4 |
| Electronics I | 4 |
| Electronics II | 4 |
| Electronics III | 4 |
| Digital Electronics | 4 |
| *General Education Courses* | |
| Suggested electives in communication skills/human relations/ social psychology | 9-12 |
| Total Credits | 65-70 |

[1] Entitled, "Biomedical Equipment Technology: Supplementary Curriculum Materials," compiled by CONSERVA, Inc.

**Biomedical Electronics Course Descriptions**

*Introduction to Biomedical Equipment Technology.* This course introduces the student to basic concepts in biomedical work. Historical origins of biomedical measurement are presented and related to types of patient monitoring equipment, laboratory equipment and testing instruments which are currently used in the medical field. The BMET is studied within the hospital or manufacturing work environment. A discussion of hospital design, departments, functions and procedures is provided. Medical terminology, required for interaction with paramedical and professional personnel and for understanding physiological parameters/measurements, is presented in some detail.

*Hospital Safety, Ethics and the Law.* Concepts of electrical safety, including methods and practices of preventive maintenance and safety in the hospital, are presented. The student is introduced to various legislation, standards and codes regarding hospital safety, such as the National Fire Protection Association codes, specifics of the Occupational Safety and Health Act, Association for the Advancement of Medical Instrumentation and National and State standards, and regulations of the Joint Commission on Accreditation of Hospitals. Record keeping as a part of equipment preventive maintenance and repair is discussed. The concepts of medical ethics and legal liability related to the BMET's functions are presented.

*Biomedical Instrumentation.* This course is a study of the basic principles by which physiological events are measured. Electronic fundamentals are used to convey an understanding of electrodes, tranducers, amplifiers and patient monitoring systems. During laboratory sessions students are acquainted with, and provided practical experience on, basic biomedical equipment and how to apply manufacturers' setup, calibration and repair procedures. Techniques introduced are reading of schematic diagrams, circuit analysis, safety inspection, preventive maintenance and troubleshooting.

*Advanced Biomedical Instrumentation.* This course is a continuation of Biomedical Instrumentation. Techniques are applied to more advanced concepts and equipment, such as cardiac monitoring, electromyography, blood gas analyzers and telemetry. The student is introduced to radiation theory and safety, including fundamentals of circuitry and design. During laboratory sessions students gain considerable exposure to troubleshooting and repair of advanced biomedical instrumentation.

*Biomedical Systems.* The components and equipment studied in earlier courses are viewed from a systems approach. The student is introduced to monitoring systems and computer controlled systems within the hospital. Microprocessors—their structure, programming, operation, application and maintenance—are presented. The student applies principles and concepts learned to a design project. The project is to construct, adapt or modify fundamental biomedical components to meet a specific need.

*Practicum.* During one or two summer sessions the student is assigned to a hospital and/or equipment manufacturer to gain insight to the work environment. The student gains practical experience through participating, under the direct supervision of a BMET, in the operation, maintenance and repair of biomedical instrumentation. The student learns through observation of personnel and equipment and increasing hands-on experience.

**Related Science and Technical Course Descriptions**

*Technical Mathematics I and II.* This series of courses is designed for technical-occupational students. Mathematical topics covered are scientific notation; basic concepts and computational aspects of plane and solid geometry; algebraic concepts and techniques; matrices and determinants; ratio, proportion and variation; systems of equations; trigonometry; complex numbers; logarithms; and an introduction to applications of differential and integral calculus.

*Applied Science.* This course is an integrated sequence of physical, chemical and biological principles relating to nonliving and living systems. The nature of science and use of measurement techniques and the scientific method are stressed. Fundamentals of applied physics and chemistry are presented. Laboratory sessions introduce principles of problem-solving and their applications. (Basic Technical Physics and Technical Chemistry courses may be substituted for this integrated approach.)

*Anatomy and Physiology.* This course introduces basic principles of the structure and function of the body. Emphasis is placed on the integration of body systems as well as the structure and functions of individual systems. Physiological processes are related to biomedical measurement and monitoring.

*Shop Technique.* This course provides an orientation to fabrication and assembly of devices. Included are an introduction to drafting procedures and care and use of tools and equipment. The student gains shop experience in soldering techniques, use of the micrometer, layout tools, cutting and bending tools and drilling and punching tools.

*DC and AC Circuits.* Lecture and laboratory sessions introduce the student to theories and applications of direct and alternating current. Concepts of resistance, current, voltage, electromagnetism, inductance and capacitance are presented. The applications of these concepts to measurement techniques and circuit analysis are also presented.

*Electronics, I, II, and III.* This is a basic introductory course series offered for electronics majors. The series offered at Milwaukee Area Technical College provides an example of course content:

- Electronics Principles and Circuits I:

  A study of basic diode circuits serves as an introduction to electronic devices. Considerable emphasis is placed on learning the techniques of circuit analysis through such topics as common symbols and conventions; load lines; loop, mesh and node equations; ideal voltage and current sources; Thevenin's and Norton's Theorems; and other basic circuit-solving techniques. The course concludes with an introduction to transistors.
- Electronics Principles and Circuits II:

  Major emphasis is placed on semiconductor circuits such as common-emitter, common-collector and common-base amplifiers; biasing and stabilization; gain and phase relationships; frequency response; coupling techniques; multistage amplifiers; feedback principles; and oscillators. In the laboratory work, the practical operating characteristics of these circuits are studied.
- Electronics Principles and Circuits III:

  This advanced course considers the use of semiconductor devices in switching circuits. Course topics include waveshaping circuitry such as pulse, logic, and sweep circuits; multivibrators; triggering; and

waveshaping techniques. Applications of the FET, UJT, SCR and IC as they apply to pulse-type circuits are introduced. In the laboratory work, the student makes full use of the calibrated oscilloscope in the study of typical pulse circuitry.

*Digital Electronics.* This course studies the logic circuits used in digital computer. Boolean algebra and number systems as applicable to logic are presented. The student is introduced to logic gates, flip-flops, decoders, logic circuits, arithmetic circuits and timing circuits. Laboratory sessions emphasize troubleshooting and practical applications.

## CERTIFICATE PROGRAM

A certificate program can be designed from the Associate Degree Curriculum, with course content depending on the needs of potential employers and the student population. Generally the certificate program is designed to serve one of three purposes:

1) To provide graduates of the curriculum with entry level skills at a lower level than the graduates of the two-year associate degree program,
2) To provide a more concentrated emphasis on technical aspects of BMET at the sacrifice of general education coursework, or
3) To provide further specialization to individuals currently employed in related occupations.

Drawing from the Associate Degree Curriculum presented in the previous section, a Certificate Program of the first type might be structured as follows:

| *Biomedical Electronic Courses* | Semester Credit Hours |
|---|---|
| Introduction to Biomedical Equipment Technology | 3 |
| Hospital Safety, Ethics and the Law | 2 |
| Biomedical Instrumentation | 4 |
| *Related Technical Coursework* | |
| Technical Mathematics I | 3 |
| Applied Science | 4 |
| Anatomy and Physiology | 3 |
| DC and AC Circuits | 4 |
| Electronics I | 4 |
| Electronics II | 4 |
| *General Education Coursework* | |
| Suggest Communication Skills | 3-6 |
| Total Credits | 34-37 |

Such a curriculum would not provide a student with all of the competencies necessary to function independently as a BMET. Consequently, graduates would work under skilled supervision and be provided with on-the-job training over a significant length of time prior to assuming responsibilities similar to those of associate degree BMET graduates. Prior to implementing a program of this nature, it is thus necessary to establish the need for, and employer willingness to hire, individuals with competencies acquired through the certificate program.

The second type of BMET certificate program consists solely of specialized coursework. A student enrolled in this type of program acquires most of the technical competencies of the student in an associate degree program. Suggested coursework from the Associate Degree Program described earlier includes Biomedical Electronics courses (17 credits), excepting Practicum; all Electronics courses (20 credits); and Anatomy and Physiology (3 credits), for a total of 40 credits.[1] However, competencies in technical mathematics and applied science must be demonstrated prior to enrollment in many of the technical courses. Thus, this type of program is most appealing to and suitable for students with some technical or science background.

This third type of certificate curriculum in BMET is designed specifically for persons who are employed as electronics technicians and who desire to expand their expertise to biomedical equipment technology. A suggested curriculum includes the coursework outlined below. Course descriptions are presented in the description of the associate degree curriculum.

| *Biomedical Equipment Coursework* | Semester Credit Hours |
|---|---|
| Introduction to Biomedical Equipment Technology | 3 |
| Hospital Safety, Ethics and the Law | 2 |
| Biomedical Instrumentation | 4 |
| Advanced Biomedical Instrumentation | 4 |
| Biomedical Systems | 4 |
| Practicum | 4 |
| *Related Science Courses* | |
| Applied Science (Technical Physics and Chemistry) | 4 |
| Anatomy and Physiology | 3 |
| *General Education Courses* | |
| Suggested electives in communications skills/human relations/ social psychology | 3-6 |
| Total Credits | 31-34 |

Because this curriculum serves a specific student population, student interest and qualifications, as well as area or regional employment demand, should be established prior to implementation. It will be necessary to offer a majority of the coursework during off-work hours since many of the students will be employed. Thus student demand for the program must be estimated, with some consideration given to the time and place where instruction may be given.

## ELECTRONICS CURRICULUM: BMET OPTION

Similar to the third type of certificate program presented above is a BMET Option offered as an adjunct to an associate degree-granting electronics curriculum. This type of curriculum is presently offered at Western Iowa Tech Community College, which operates on a quarter system. The BMET Option consists of a six-quarter electronics curriculum, supplemented with an extra quarter of coursework devoted to biomedical equipment technology. The curriculum is outlined below, followed by descriptions of BMET courses. Descriptions of additional coursework are presented in Western Iowa Tech's catalog.

[1] Suggested curriculum is based on certificate of achievement program offered at Tulsa Junior College, Tulsa, Oklahoma.

| *First Quarter* | Contact Hours | Quarter Credit Hours |
|---|---|---|
| Electronic Drafting I | 60 | 3 |
| Math I | 72 | 6 |
| Electronics Circuits I | 168 | 9 |
| Communications Skills | 60 | 5 |
| *Second Quarter* | | |
| Electronic Circuits II | 132 | 8 |
| Electronic Drafting II | 36 | 2 |
| Math II | 72 | 6 |
| Vacuum Tube Fundamentals | 48 | 3 |
| Test Instruments I | 72 | 4 |
| *Third Quarter* | | |
| Semiconductor Fundamentals | 156 | 9 |
| Math III | 60 | 5 |
| Circuit Tracing and Printed Circuit Design | 48 | 2 |
| Test Instruments II | 72 | 4 |
| Electronic Circuit Analysis Program | 24 | 2 |
| *Fourth Quarter* | | |
| Pulse Switching Circuits | 156 | 9 |
| Computer Science | 48 | 4 |
| Transistor Circuit Analysis | 72 | 4 |
| Integrated Circuits | 84 | 5 |
| *Fifth Quarter* | | |
| Physics I | 60 | 4 |
| Digital Computer Fundamentals I | 96 | 6 |
| Receivers and Transmitters | 96 | 6 |
| Human Relations | 36 | 3 |
| Troubleshooting Techniques | 72 | 4 |
| *Sixth Quarter* | | |
| Physics II | 36 | 3 |
| UHF and Microwaves | 120 | 7 |
| Servomechanisms Fundamentals and Industrial Controls | 72 | 4 |
| Special Projects | 48 | 2 |
| Digital Computer Fundamentals II | 84 | 5 |
| *Seventh Quarter* | | |
| Integrated Science I | 96 | 6 |
| Body Structure and Function | 60 | 5 |
| Medical Terminology I | 60 | 3 |
| Internship | 144 | 6 |

**Course Descriptions (Seventh Quarter)**

*Integrated Science I.* A comprehensive course comprised of selected principles of physics, chemistry and microbiology with emphasis on these principles as they apply to structure and function of the human body and their application in nursing. The course provides for independent study in depth of medical surgical patients.

*Body Structure and Function.* The primary aim of this course is to introduce the student to principles of biological and physical sciences that contribute to understanding the human body processes in normal and certain abnormal conditions. Content includes science of anatomy (body structure), physiology (function), disease processes (pathology) and very basic concepts of microbiology and chemistry which relate to the body processes.

*Medical Terminology.* This course provides an orientation to the medical profession via terminology. In this quarter the basic words are taught with an overview of the Anatomy and Physiology of the body.

*Internship.* Supervised experience is offered in cooperating agencies to broaden the student's knowledge and skills in biomedical electronics. Areas to be emphasized are organizational structure, practical experience on equipment, reading schematics, interpretation of manuals, routine maintenance and troubleshooting techniques.

## SUMMARY

The approaches presented in the foregoing discussion were chosen and designed to best represent the biomedical equipment technician curricula which are currently in operation in the United States. The associate degree curriculum, the certificate curriculum and the BMET option, as presented, are the most common approaches to providing individuals with entry-level skills and knowledges. However, variations in instructional modes do occur. One such variation is a self-paced modular approach which was developed at 916 Area Vo-Tech Institute in White Bear Lake, Minnesota. The curriculum, which consists of 80 individualized packets, can be obtained from the Minnesota Instructional Materials Center and adapted to suit regional needs in Illinois. The transferability of the curriculum system is evidenced by its adoption by Stevenson Area Career Center in Freeport, Illinois. The competencies which the program provides are listed in Appendix D.1.

Another variation of the associate degree curriculum is the manner in which student work experience may be gained. Work experience is considered a vital part of a BMET curriculum, but institutions differ in their philosophies of the most effective modes of providing such experience. A practicum, which can be split into two periods of internship, was included in the suggested associate degree curriculum. Alternatively, institutions may participate in apprenticeship or cooperative education activities. Both of these options place a heavier emphasis on the role of work experience in preparing BMETs than does the associate degree curriculum suggested earlier. Apprenticeship, such as that in operation in Southern California, requires that apprentices work 40 hours a week in cooperating hospitals for the length of apprenticeship (four years). Forty-six hours of required coursework must be completed concurrent with the apprenticeship. Since the apprentice is a full-time employee with increasing competencies and levels of responsibility, he/she receives wages throughout the four-year apprenticeship period. On the other hand, a cooperative program requires only part-time work experience of the students. Such a program, in operation at Schoolcraft College in Livonia, Michigan, involves two semesters of full-time work at cooperating hospitals and two semesters of class and laboratory work at the college. While the graduate of the cooperative program

has the advantage of considerable work experience obtained as part of the curriculum, he/she is not admitted to "journeyman" status as the apprentice is at the completion of the program.

Dependent on area employment and student characteristics, additional variations in scope, length and emphases of curricula used to train BMETs occur. As was noted earlier, curriculum outlines, course descriptions and course outlines from a variety of BMET programs across the country are contained in a document accompanying this report. A review of these curricula may prove useful before initiating a BMET curriculum.

# V. RESOURCE REQUIREMENTS

Presented in this chapter are the resources required to implement a program in biomedical equipment technology. The first section outlines the composition of a curriculum advisory committee, which is an essential component of curriculum development and maintenance. This is followed by discussions of the facilities and equipment and instructor resources needed to implement a program. These two sections will be useful in (1) determining whether an institution posseses the resources essential to the establishment of a BMET curriculum and (2) planning for the acquisition of needed resources.

**Curriculum Advisory Committee**

Though a curriculum advisory committee performs almost entirely in an advisory capacity, its input to program development and maintenance is often critical. As noted in Chapter II, the advisory committee participates in most of the curriculum development process. Once a curriculum is established the committee continues to provide support by assisting in cooperative arrangements and job placement, reporting developments in the field which require curriculum modifications, evaluating the performance of graduates and recommending curriculum modifications based on the evaluation, and serving as a link between the school and the community.

Advisory committee membership should represent the various disciplines which contribute to and benefit from biomedical equipment technology. Both employers and employees are desirable on a committee. Additionally, if consistent with the institutional policy, faculty from the electronics, allied health and engineering, as well as BMET departments should be represented on the committee. The committee should also include a graduate of a BMET curriculum and a student member. Typically, membership ranges from six to twenty representatives; however, eight to twelve can be considered a reasonable size for a committee. The following list identifies potential representatives for a BMET program advisory committee.

- BMET Faculty
- Engineering Faculty
- Allied Health Faculty
- Electronics Faculty
- Secondary Vocational Electronics Instructors
- Program Graduates
- Students
- Clinical Engineers
- Hospital Administrators
- Employed, certified BMETs
- Physicians
- Representatives of related local associations or organizations
- Hospital Plant Engineers
- Representatives of shared service organizations
- Representatives of biomedical equipment manufacturers
- Representatives of military biomedical maintenance
- Union Representatives

**Facilities and Equipment**

Facilities required for implementing a program in biomedical equipment technology include standard classrooms (equipped with teaching aids) and adequate laboratory space for equipment required to support BMET and related technical coursework. TERC recommends 1500 square feet of laboratory space devoted to BMET in addition to space for related science and technical course laboratory sessions (Technical Education Research Centers, 1975).

A major investment of institutions desiring to implement a BMET program is the equipment needed to provide fully equipped laboratory facilities. Though there will generally be a large initial investment in biomedical equipment, expenditures can be minimized by requesting assistance from other sources. Oftentimes allied health and nursing program utilize biomedical equipment as part of clinical course requirements (e.g., ECG, EEG, medical laboratory equipment or X-ray machine). If course schedules can be coordinated so as to allow BMET instructors to utilize allied health laboratories, equipment expenditures can be reduced. Also, hospitals and/or equipment manufacturers are willing to donate modern equipment for use in the BMET curriculum at the institution. Modern, current equipment is essential in a BMET curriculum, since much of the equipment is designed to maintain and prolong life in emergency situations. Hospital-discarded equipment and manufacturers' discontinued models cannot provide the currency and efficiency needed in a curriculum such as BMET. Only in circumstances where components of the discontinued equipment are still up-to-date and usable should consideration be given to the acceptance of such donations. Priorities in equipment purchases can be established with the assistance of the curriculum advisory committee.

In addition to standard work benches, tools, sinks, fans, hoods, storage areas, etc., the BMET laboratory must contain medical and test equipment with which students can gain experience. Types of equipment most commonly found in BMET training laboratories are test instruments, surgical instrumentation, monitoring and measuring equipment and radiology equipment. Lists of specific items which are used in BMET programs are presented in Appendix G. A review of these lists will assist in planning a BMET laboratory.

**Instructor Qualifications**

Essential qualifications of a BMET instructor are a background in electronics and experience in biomedical equipment technology. Various combinations of education and experience can serve as prerequisites to employment as a BMET instructor. Unless institutional requirements specify otherwise, a degree is desirable but not required. A background in electronics and 2-5 years experience as a BMET may qualify an individual as an instructor. Graduates of four-year institutions, with degrees in electrical engineering, electronic engineering or biomedical engineering, are also candidates for faculty positions. However, some experience in the field is also highly desirable. Qualifications must exhibit a balance in theory and application in order that sufficient skills and knowledge can be communicated to the students. Additionally, instructors must be willing and able to keep abreast of changes in the field and adapt coursework in response to new developments.

BMET curricula generally employ one instructor to teach specialized BMET courses. Other coursework constituting the curriculum is shared with various technical or science

curricula (e.g., electronics or mathematics) and thus may be taught by instructors drawn from those areas. Larger programs may employ more than one BMET instructor; however, they generally teach electronics courses in addition to BMET. Typically, one full-time BMET instructor is required for each 20-30 students.

# VI. ABSTRACTS OF CURRICULUM MATERIALS

This chapter contains abstracts of curriculum and instructional materials that were identified during the process of procuring curriculum information from BMET programs nationwide. Abstracts of curriculum materials are presented in the first section, followed by abstracts of instructional materials. Four major types of materials, which can serve to supplement this guide in planning and developing a BMET curriculum, are presented in the first section:

- Curriculum Guides
- Catalogs
- Bibliographies
- Program Digests

Various instructional and learning materials are abstracted in the second section of this chapter. They have been classified as follows:

- Texts or References
- Training Manuals
- Codes and Standards
- Audio Visuals

These instructional materials provide a good foundation for offering coursework in biomedical equipment technology. An additional source of learning materials is local equipment manufacturers or distributors. Equipment manuals are frequently used as instructional resources, and their availability should be investigated during equipment procurement. Other supplementary resources are journals or periodicals and standards. A list of relevant journals and periodicals is presented in Appendix H. This is followed by a listing of AAMI standards and technical documents (Appendix I).

While the instructional materials presented in this guide provide a good foundation in terms of available instructional materials, the reader is advised to keep informed of new developments in the rapidly changing field. Reading current literature, e.g., journals or newsletters, is one means of keeping informed. Additionally, by maintaining close contact with curriculum advisory committee members and employers of BMETs, instructors will be able to adapt their programs of instruction to keep in step with technological innovations.

# CURRICULUM MATERIALS

Title: BIOMEDICAL ELECTRONICS MONOGRAPH
Author: William G. Welch
Publisher: Western Wisconsin Technical Institute Center for State Vocational, Technical and Adult Education District No. 2
Sixth and Vine Streets
LaCrosse, WI 54601
Year: Undated, circa 1972
No. of Pages: 152
Cost: No Charge

This monograph describes the Biomedical Electronics Associate Degree Program at Western Wisconsin Technical Institute. Included is the curriculum (as of September 1971), course descriptions and outlines of courses composing the curriculum. Other sections of the monograph describe the program in terms of physical facilities and equipment, supervision and administration, instructional qualifications and duties, the program advisory committee, student services and activities, program schedules and plans for future program development. By describing the Western Wisconsin Technical Institute Program in such detail, the monograph offers a useful resource for new program development.
*CURRICULUM GUIDE*

Title: BIOMEDICAL EQUIPMENT TECHNOLOGY: SUPPLEMENTARY CURRICULUM MATERIALS
Compiled By: CONSERVA, Inc.
Available for Review from: East Central Curriculum Coordination Center
100 North 1st Street
Springfield, IL 62777
Year: 1979

This document is a compendium of selected BMET curricula which are currently in operation nationwide. Included are curriculum outlines, course descriptions, and course outlines which were collected by CONSERVA from the various institutions. The following is a list of community colleges, technical institutes and other institutions represented in the document:

- Kaiser Foundation Hospital
- Oakton Community College
- United Electronics Institute
- Western Iowa Technical Community College
- Howard Community College
- Schoolcraft College
- Hennepin Technical Center, South Campus
- St. Louis Community College at Oak Park
- Tulsa Junior College
- Temple University
- Amarillo College
- St. Phillips College
- Texas State Technical Institute
- Utah Technical College at Salt Lake
- Spokane Community College
- Milwaukee Area Technical Institute
- Western Wisconsin Technical Institute

*CURRICULUM GUIDE*

Title: A COMPREHENSIVE PROGRAM FOR TEACHING ELECTRONICS AND MEDICAL INSTRUMENTATION
Author: PASCO Scientific
Publisher: PASCO Scientific
1933 Republic Avenue
San Leandro, CA 94577
Year: 1977
No. of Pages: 71
Cost: No Charge

This guide, which is extracted from a more complete sales binder developed by PASCO, presents information about the BMET field and education of the BMET. The first section of the document describes the biomedical equipment technician profession through a sample job description, an article reprinted from the *Journal of Clinical Engineering*, certification requirements and demand figures. This is followed by a section which discusses education of the BMET and presents sample curricula. Finally, the program/equipment needs for teaching in BMET are presented in the third part of the binder. This section describes PASCO's involvement in BMET and the specific equipment which PASCO has developed. Also included are specifications for the biomedical instrumentation equipment and a recommended equipment list. Appended is a 16-page sales brochure.
*CURRICULUM GUIDE*

Title: SPECIAL PACKAGE OF INSTRUCTIONAL RESOURCES FOR BIOMEDICAL EQUIPMENT TECHNOLOGY
Author: The National Center for Research in Vocational Education
Publisher: The National Center for Research in Vocational Education
1960 Kenny Road
Columbus, OH 43210
Year: 1978

This document is one of a series of "Special Packages" developed for the dissemination of easily-adaptable curriculum information on growing and developing occupations. The BMET package consists of six sections, five of which compose the first volume of the guide and a sixth which comprises Book 2. Contained within the first section are articles and research studies of the BMET occupation. Section II contains training requirements information, including an instructional program outline from Denver Public Schools, the BMET program at Johnson County Community College (Kansas), task analyses of the BMET occupation performed by 1) Technical Education Research Centers (TERC) and 2) Denver Public Schools, and "A Suggested Two Year Postsecondary Curriculum" developed by TERC. Section III presents equipment and instructional resources recommended by the Denver Public Schools and Section IV lists biomedical instrumentation organizations and college level programs. Contained within the fifth section are military medical equipment standards and a "Study Guide for VA Radiological Instrumentation Certification Exam in Biomedical Engineering Technology." The final section (Book 2) presents modules and outlines of instruction for biomedical equipment maintenance and repair from the Career Education Center, Denver Public Schools.
*CURRICULUM GUIDE*

Title: THE DIRECTORY OF AUDIOVISUAL AIDS FOR CLINICAL ENGINEERS & BMETS
Author: Brenda E. Arnold & A.F. Parcla
Publisher: Quest Publishing Company
P.O. Box 4141
Diamond Bar, CA 91765
Year: 1977 (First Edition)
No. of Pages: 41
Cost: $4.50 (Paperback)

This directory lists and abstracts a wide variety of audiovisual aids for use in training Clinical Engineers and Biomedical Equipment Technicians. Audiovisuals are presented for the key areas of diagnostics, therapy, surgery and prosthetics as they relate to biomedical equipment technology. Other general subject areas for which audiovisuals are presented are safety (including hospital electrical safety) and engineering. These six general topics are broken into subtopics to facilitate use of the directory. Each annotation listed includes the title of the audiovisual, the type of audiovisual, whether it is in black and white or color, the running time, the release date, a brief description of the subject of the audiovisual, a reference number (when available) and the source(s) from which it can be obtained. An index of titles is also provided.
*CATALOG*

Title: HEWLETT-PACKARD APPLICATION NOTES
Author: Application Notes Editor
Publisher: Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, CA 94304
Cost: No Charge

Hewlett-Packard (HP) has developed a series of "application notes" which address various operational characteristics of equipment. Though the notes are written by HP engineers and customers and are thus geared to specific HP equipment (electronic instruments, computers, calculators, medical electronics, components and analytical instruments), they can be excellent supplementary instructional materials. A catalog, which abstracts available application notes, can be obtained from the above address. The catalog includes, in addition to note abstracts, subject and product model number indexes. Twenty-five application notes are currently available in the area of medical electronics. An example application note, Guide to Physiological Pressure Monitoring, AN 739, is abstracted in this chapter.
*CATALOG*

Title: 1979 NATIONAL FIRE PROTECTION ASSOCIATION PUBLICATIONS AND VISUAL AIDS CATALOG
Publisher: National Fire Protection Association
Publications Sales Department
470 Atlantic Avenue
Boston, MA 02210
Year: 1979
No. of Pages: 48
Cost: No Charge

This catalog lists and abstracts Codes, Standards, audiovisuals and other publications currently available from NFPA. The following NFPA standards have been recommended as instructional resources in biomedical equipment technology:

NFPA 56A Inhalation Anesthetics
NFPA 56B Respiratory Therapy
NFPA 56C Laboratories in Health-Related Institutions
NFPA 56D Hyperbaric Facilities
NFPA 56E Hypobaric Facilities
NFPA 56F Nonflammable Medical Gas Systems
NFPA 56G Inhalation Anesthetics in Ambulatory Care
NFPA 70-78 National Electrical Code
NFPA 76A Essential Electrical Systems for Health Care Facilities
NFPA 76C Safe Use of High-Frequency Electricity in Health Care Facilities (Recommended Practice)

Other NFPA publications and audiovisuals are also useful training materials on hospital fire safety.
*CATALOG*

Title: DEVELOPMENT OF CAREER OPPORTUNITIES FOR BMETS: DIGEST OF EDUCATIONAL MATERIALS
Author: Technical Education Research Centers, Inc.
Publisher: Technical Education Research Centers, Inc.
44 Brattle Street
Cambridge, MA 02138
Year: 1972
Cost: $21.50

This digest is an annotated bibliography of educational materials in biomedical equipment technology. Though somewhat outdated, the digest can serve as a guide in curriculum development. The first section contains annotations of manufacturers' literature, such as pamphlets, laboratory manuals, reference manuals, films, service manuals, etc. The second section presents textbooks and lab manuals related to biomedical equipment technology. The third section includes reference works such as medical dictionaries and source catalogs. Provided in each of the sections are both a title and author index.
*BIBLIOGRAPHY*

Title: SELECTED REFERENCES ON FUNCTIONAL PROGRAMMING, EQUIPPING, AND DESIGNING HEALTH CARE FACILITIES
Author: U.S. Department of Health, Education, and Welfare; Public Health Service; Health Resources Administration; Division of Facilities Utilization
Publisher: U.S. Department of Health, Education, and Welfare
5600 Fisher's Lane
Rockville, MD 20852
Stock No.: HEW No. (HRA) 75-4008
Year: 1974
No. of Pages: 46
Cost: No charge for single copies

This publication identifies references on hospital planning, equipping and design. The references are grouped into the following areas:

- Architecture
- Burn Unit
- Coronary Care and Intensive Care Units
- Dietary
- Electrical Engineering
- Emergency Room
- Equipment
- Housekeeping
- Infections Control
- Laundry
- Mechanical Engineering
- Nursing
- Outpatient
- Patient Education
- Pharmacy
- Rehabilitation
- Shared Services
- Solid Wastes
- Surgical Suite

Publisher addresses are also provided.
*BIBLIOGRAPHY*

Title: SELECTED REFERENCES ON HOSPITAL EQUIPMENT
Author: U.S. Department of Health, Education, and Welfare; Health Services and Mental Health Administration; Health Care Facilities Service; Office of Equipment Consultation
Publisher: U.S. Department of Health, Education, and Welfare
5600 Fisher's Lane
Rockville, MD 20852
Stock No.: HEW No. 73-4039
Year: 1973
No. of Pages: 48
Cost: No charge for single copies

This publication identifies references, primarily journal articles, on hospital equipment. The references are categorized into the following areas:

- Automation
- Computers
- Costs
- Disposables
- Electronics in Modern Medicine
- General
- Laser in Medicine
- Leasing
- Maintenance
- Medical Devices
- Monitoring
- Purchasing
- Safety
- Shared Services
- Standards

Publisher addresses are also provided. The publication is a consolidation of seven previous issuances (May 1969-May 1972) of the Office of Equipment Consultation.
*BIBLIOGRAPHY*

Title: DIGEST OF EDUCATION PROGRAMS: BIOMEDICAL EQUIPMENT TECHNOLOGY
Author: Technical Education Research Centers, Inc.
Publisher: Technical Education Research Centers, Inc.
44 Brattle Street
Cambridge, MA 02138
Year: 1974
No. of Pages: 324
Cost: $15.00

This digest describes 32 BMET programs at the technician level in community colleges, technical institutes and military facilities operational as of September 1972. The first part of the report provides a descriptive listing of the programs. Each school listing includes: the BMET Program Director, background information on the institution, allied health concentrations, technical concentrations, BMET placement resources, BMET program description, work experiences, instructors, laboratory space, funding, enrollment, placement, entrance requirements, tuition costs and transfer of credit. An introductory section summarizes the data from the individual schools.

The second part of the digest lists the curricula of 26 of the 32 institutions. A curriculum summary table, a course sequence summary and course descriptions are provided in each listing. Again, a summary of the curricula is presented. In the third part of the digest, planned BMET programs and 4-year programs are listed. Additionally, a paper presented at the eighth conference of the Association for Advancement of Medical Instrumentation, entitled, "Training Biomedical Equipment Technicians: A Seven Year Perspective" is included.
*PROGRAM DIGEST*

# INSTRUCTIONAL MATERIALS

Title: BIOLOGICAL FOUNDATIONS OF BIOMEDICAL ENGINEERING
Author: Jacob Kline (Editor)
Published: Little, Brown and Company, Inc.
Medical Division
34 Beacon Street
Boston, MA 02106
Year: 1976
No. of Pages: 988
Cost: $35.00

"This text is divided into eight sections. It begins with the basic sciences, treating the biochemical, thermodynamic, metabolic, and bioelectric topics needed for the understanding of many of the processes covered later. The seven sections that follow present the major mammalian organ systems from a functional point of view, with an emphasis, when possible, on a systems approach. The cardiovascular, respiratory, body fluids, nervous, endocrine, gastrointestinal, and reproductive systems are considered individually. Throughout, an attempt is made to consider relationships and interactions among the systems. Each section is developed by first presenting the basic concepts and organization of the organ system in such a manner that the reader may understand its function without any prior exposure to biology or physiology. Later chapters in each section become more sophisticated with the use of mathematics and engineering concepts, where they may apply, to quantify and make more understandable the biological functions. Several chapters include instrumentation dealing with the measurement of physiological and diagnostic parameters, as well as therapeutic techniques." (Excerpts from author preface)

Although this book was designed for instruction in biomedical engineering, portions of the text may be suitable for teaching at the community college level. Additionally, it may serve as a useful instructor reference.

*TEXT OR REFERENCE*

Title: BIOMEDICAL ELECTRONICS
Author: Howard M. Yanoff
Publisher: F.A. Davis Company
1915 Arch Street
Philadelphia, PA 19103
Year: 1972 (Second Edition)
No. of Pages: 545
Cost: $20.00

*Biomedical Electronics* is designed for use as a text or reference book in biomedical instrumentation. The book gives a fairly comprehensive overview of fundamentals of electronics, including chapters on basic physical concepts; introduction to alternating current circuits; measurement of voltage, current and impedance; the vacuum tube; diodes and transistors; the oscillator; digital circuitry and the computer; and noise and its elimination. The author attempts to relate electronic theory to biomedical applications whenever possible. The second section of the book deals with biomedical instruments. The chapters include general remarks on biomedical instruments, the transducer, bioelectric measurements, and the output signal and what to do with it. Numerous graphs, figures, circuit diagrams and photographs are presented throughout the book.

*TEXT OR REFERENCE*

Title: BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS
Authors: Leslie Cromwell, F.J. Weibell, E.A. Pfeiffer, & L.B. Usselman
Publisher: Prentice-Hall, Inc.
Englewood Cliffs, NJ 07632
Year: 1973
No. of Pages: 446
Cost: $19.95

*Biomedical Instrumentation and Measurements* is designed as a general reference to medical instrumentation as well as a textbook for teaching coursework in biomedical equipment technology. The book first provides an overview of human physiology and sources of bioelectric potentials. Various systems of the body are discussed and related to biomedical measuring and monitoring instruments. Additionally, biotelemetry, clinical laboratory, X-ray and radioisotope, and computerized instrumentation are discussed. A final chapter addresses electrical safety as it applies to medical equipment. Numerous illustrations, diagrams and photographs and a glossary of relevant medical terminology clarify the presentation of material. A summary of physiological measurements, average values for lung function tests, and problems and exercises are also appendicized.

*TEXT OR REFERENCE*

Title: BIOPHYSICAL MEASUREMENTS
Author: Peter Strong
Publisher: Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97005
Year: 1970
No. of Pages: 499
Cost: $10.00 (Paperback)

"It is the intent of this publication to familiarize engineering personnel with electronic measurements associated with the biophysical sciences. As such, a developed knowledge of electronics and electronic measuring techniques is assumed, but biological and physiological aspects are presented from first principles and simplified to a level consistent with the understanding of the basic principles involved. Information is separated into the following categories:

Section I — Physiology and generation of bioelectric potentials within man.
Section II — Measurement techniques required to perform various biophysical measurements.
Section III — Instrumentation required to implement the measurement techniques covered in Section II.

A reader wishing to study, for example, electrocardiographic techniques, should thus first study Section I, Chapter 2, to determine the source of the bioelectrical potential referred to as the electrocardiogram; [she/] he should then study Section II, Chapter 5, to determine the measurement techniques necessary in recording this electrocardiogram and, finally, he [/she] should then study Section III to determine the instrumentation necessary to implement these measurement techniques.

In general, only commonly accepted and widely used measurement techniques are covered in this publication as it would be impossible to document the infinite variety of unique, specialized, biophysical measurements being performed by different clinicians and researchers in the biophysical sciences. This publication should not be interpreted as a general text on medical electronics; it is, as its title implies, limited to measurement techniques." (Excerpts from Author Preface)

*TEXT OR REFERENCE*

Title: DESCRIPTIVE MEDICAL ELECTRONICS AND INSTRUMENTATION
Author: Terence C. Karselis
Publisher: Charles B. Slack, Inc.
6900 Grove Road
Thorofare, NJ 08086
Year: 1973
No. of Pages: 373
Cost: $15.95

This book is designed for use as a text in teaching basic medical electronics to allied health students, such as medical technologists, physical therapists, bioengineering technologists, in addition to nurses and medical students. Material regarding electronics and instrumentation is presented with a descriptive rather than analytical approach. The first part of the book deals with basic electricity and electronics. This is followed by a survey of clinical analytical instrumentation. The final section discusses medical instruments and devices and hazards, safety and instrumentation. Appended is a glossary of electronic terms.
*TEXT OR REFERENCE*

Title: ELECTRICAL SAFETY IN HEALTH CARE FACILITIES
Authors: Herbert H. Roth, E.S. Teltscher, & I.M. Kane
Publisher: Academic Press
111 Fifth Avenue
New York, NY 10003
Year: 1975
No. of Pages: 218
Cost: $21.75

This book describes electrical safety principles in hospitals, discusses factors contributing to unsafe electrical systems and outlines maintenance procedures for assuring safe electrical systems in hospitals. An introduction to electricity and electrical systems in the hospital is provided, followed by a discussion of the electrical environment and the hazards which it may impose on the patient. The next three chapters present safety installation methods for electronic equipment, patient-protection systems and safety testing. Finally, procedures for establishing a safety, preventive-maintenance and repair program in a hospital are presented. A number of practical appendices are also included in the text as are bibliographies with each chapter. Extensive use of diagrams and graphs is made to clarify written material.
*TEXT OR REFERENCE*

Title: ELECTRONICS FOR HOSPITAL PATIENT CARE
Author: Noyce L. Griffin
Publisher: U.S. Department of Health, Education, and Welfare
Public Health Services
Health Services and Mental Health Administration
Health Facilities Planning and Construction Service
Office of Architecture and Engineering
Silver Spring, MD 20910
Stock No.: PHS No. 930-D-25
Year: 1968
No. of Pages: 66
Cost: No charge for single copies

"This publication is divided into two parts. Part I contains a revision and expansion of publication No. 930-D-12, *Electronic and Related Electrical Equipment in Hospitals*, 1963. Part II contains a report of a recent on-site study of current practices of electronic monitoring of patients, needs of facilities and equipment, and trends in the use of electronics that are expected to stimulate development and improvement of equipment, affect future planning of facilities, and emphasize the need for enlightenment in the field of bioelectronics. The main bodies of Parts I and II briefly describe the subjects to provide an overall picture for those not concerned with technical details. For those who wish additional information, the Appendixes contain further particulars, statistics, and illustrations." (Excerpted from Foreword of document)

Though somewhat outdated this publication provides some useful guidelines.
*TEXT OR REFERENCE*

Title: GUIDE TO PHYSIOLOGICAL PRESSURE MONITORING
Author: Hewlett-Packard (Application Note AN739)
Publisher: Hewlett-Packard Company
175 Wyman Street
Waltham, MA 02154
Year: 1977
No. of Pages: 63
Cost: No charge to HP customers

This application note describes pressure monitoring first from an historical perspective and subsequently in terms of practicality. An overview of different techniques and instruments used to measure blood pressure is provided in addition to the theory on which their operation is based. Measurement problems and complications are discussed and presented in terms of waveform artifacts. The third section of the application note presents guidelines for using a pressure measurement system, including materials selection, maintenance checks, calibration procedures, set up procedures and equipment care. An appendix provides a more detailed account of the physics of pressure measurement.
*TEXT OR REFERENCE*

Title: HANDBOOK OF BIOMEDICAL INSTRUMENTATION AND MEASUREMENT
Author: Harry E. Thomas
Publisher: Reston Publishing Company, Inc.
11480 Sunset Hills Road
Reston, VA 22090
Year: 1974
No. of Pages: 550
Cost: $29.95

"Through the use of this text, the pretesting, monitoring, and intelligent control of hospital electronic instruments are made possible. This book directly relates anatomical and physiological data with the associated electronic hardware to assist the lower level, support, and operating personnel as well as the biomedical engineer and supervisory physician. The anatomical review, the statements of equipment purpose and methods, plus the lists and discussions of the various bodily functions and parameters all contribute toward more efficient service by hospital personnel.

Not only are the basics of clinical medicine explained—chromotography, electrophoresis and automatic blood analysis—but the basics of sensory measurement (transducers) plus the treatment of eye, ear and muscle treatment instruments and testing technology are covered in depth. Hospital monitoring, organization, set-ups and patient safety procedures are all included.

The text is structured heavily toward cardiac emergency, intensive care, and support equipment, particularly electrocardiography. The cardiac material is paralleled with pulmonary instrument data and operation. With the exception of electrocardiography, this book does not cover system approaches. Accordingly, the book does not detail the operation and management of surgical assembly complexes, the heart-lung machine, kidney machines, anaesthesiology set-ups, computer-controlled data or diagnostics. The specific hardware descriptions are more fitted to the personnel at operational rather than diagnostic levels. These descriptions are down to earth and very well illustrated." (Publisher review)
*TEXT OR REFERENCE*

Title: HANDBOOK OF ELECTRONIC SAFETY PROCEDURES
Author: Edward A. Lacy
Publisher: Prentice-Hall, Inc.
Englewood Cliffs, NJ 07632
Year: 1977
No. of Pages: 269
Cost: $15.95

This book describes hazards commonly encountered by the electronics technician. The detrimental effects of each of the potential hazards are discussed as are measurement methods, safety precautions and protection devices when appropriate. The following hazards are addressed in the book:

- Electric shock
- Static electricity
- Lightning
- Radiation
- Lasers
- Ladders, towers and other aerial hazards
- Underground hazards
- Toxic and explosive chemicals
- Noise
- Tools

Additionally, a chapter on product safety and appendices are included.

*TEXT OR REFERENCE*

Title: HANDBOOK OF PHARMECEUTICAL AND CLINICAL MEASUREMENT AND ANALYSIS
Author: Harry E. Thomas
Publisher: Reston Publishing Company, Inc.
11480 Sunset Hills Road
Reston, VA 22090
Year: 1977
No. of Pages: 320
Cost: $29.95

"This technical/medical volume discusses the theory, procedures, and operation of equipment associated with clinical and pharmaceutical technology. It is designed to cover three principal areas: broad clinical physiology, particularly the dynamic biophysical aspects; clinical pharmaceutics and the applicable drug therapy; and the pure pharmaceutics of the drugs and substances indicated by diagnosis or physiological analysis. The author gives a balanced approach that combines study of the principles of clinical laboratory methods with those of the pharmaceutical sciences, particularly emphasizing the equipment and physical features important to them both.

The handbook covers the basics of analytic chemistry which leads to the development of the measurement and electronic hardware used in the identification, quantization and analysis of drugs, medicine and bodily substances. Early chapters give a capsulized reference to inorganic and organic chemistry based on molecular and atomic relationships. The primary emphasis is on the process, instruments and equipment used in preparing, testing and analyzing medical and physical properties. Additional chapters discuss the substance-based technologies of chromotography, spectrophotometry, microscopy (optical and electron) and radio isotopes.

This book and its appendices also give condensed background information on the measurement of pharmaceutical and clinical substances. Specific hardware is pictured, functionally described and operationally detailed in applications and specifications. For maintenance, supervision and diagnostic applications, instrumental details cover testing, repair, installation, and purchasing." (Publisher review)

*TEXT OR REFERENCE*

Title: HOSPITAL INSTRUMENTATION CARE AND SERVICING FOR CRITICAL CARE UNITS
Author: Robert B. Spooner (Editor)
Publisher: Instrument Society of America
400 Stanwix Street
Pittsburgh, PA 15222
Year: 1977
No. of Pages: 188
Cost: $9.50
Study Guide: $3.00

Provided in this book are descriptions of a number of types of biomedical instruments. Designed for use in training of or reference by biomedical equipment technicians, the descriptions include such information as the physiological background of the instrument, block diagrams of how the instrument operates, operation and standards, artifacts of the instrument, and preventive maintenance and troubleshooting procedures. The book deals with the following hospital instrumentation:

- EKG Amplifiers
- Arrhythmia Monitors
- Blood Pressure Instruments: Direct Systolic/Diastolic Measurement
- Blood Pressure Instruments: Noninvasive, Arterial Measurement
- Electronic Thermometers
- Respiratory Monitors
- Oxygen Monitors
- Blood-Gas Analyzers
- Cardiac-Output Analyzers
- Medical CRT Displays
- Recorders
- Cardiac Pacemakers
- Defibrillators

Additionally, chapters describing test equipment and safety in the ICU/CCU are included.

*TEXT OR REFERENCE*

Title: INTRODUCTION TO BIOMEDICAL ELECTRONICS
Author: Edward J. Bukstein
Publisher: Howard W. Sams & Co., Inc.
4300 West 62nd Street
P.O. Box 558
Indianapolis, IN 46206
Year: 1973
No. of Pages: 208
Cost: $6.50 (Paperback)

This introductory text provides an overview of some of the more common biomedical equipment and instruments used in hospitals. The specific types of equipment addressed are:

- Biomedical recording systems
- Electrocardiographs
- Monitor oscilloscopes
- Heart rate monitors
- Blood pressure monitors
- Patient monitoring systems
- Fetal monitors
- Defibrillators
- Pacemakers
- Phonocardiographs
- Telemetry
- Digital Computers

Numerous photographs, graphs, specifications and circuit diagrams are provided to illustrate operation, trouble-shooting and maintenance of the equipment. Also included are chapters dealing with medical terminology, electrophysiology of the heart and electrical safety. The booklet "Electrical Safety Test Procedures for Hospitals," published by Instrutek, Inc. of Annapolis, Maryland, is reproduced as an appendix to the book.

*TEXT OR REFERENCE*

Title: INTRODUCTION TO BIOMEDICAL ELECTRONICS
Author: Joseph DuBovy
Publisher: McGraw-Hill Book Company
College Division
Manchester Road
Manchester, MO 63011
Year: 1978
No. of Pages: 382
Cost: $13.50

This book, as its title suggests, is designed to introduce the student to biomedical equipment technology. Early sections of the book provide an overview of the signals produced by the body and the conversion of physiological changes into electrical signals. Included are chapters addressing interference and instability, fidelity and patient safety considerations. The book goes on to discuss ultrasonics, telemetry, and biomedical computers and microprocessers in theory and application to medical electronics. Finally, descriptions of common biomedical circuits and trouble-shooting biomedical components and systems are provided. The text is supplemented with numerous figures, circuit diagrams and photographs. Additionally, questions to test the reader's comprehension of presented information are included at the end of each chapter. An instructor's manual, which presents brief guidelines for teaching subject matter contained in each of the book's chapters, is also available.

*TEXT OR REFERENCE*

Title: LABORATORY INSTRUMENTATION
Authors: Robert Hicks, J.R. Schenken, & M.A. Steinrauf (Editors)
Publisher: Harper & Row Publishers, Inc.
10 East 53rd Street
New York, NY 10022
Year: 1974
No. of Pages: 224
Cost: $13.50

Though designed primarily for teaching medical technologists, this book also can serve as a useful reference or introduction to laboratory instrumentation for BMETs. The first chapter of the text gives an overview of electrical principles. Each subsequent chapter addresses a different type of laboratory measurement and includes a comprehensive set of definitions. Principles and methods of measurement as well as instrument components are provided, accompanied by figures when appropriate. The following measurements/instruments are discussed:

- Spectrophotometry
- Flame Photometry
- Atomic Absorption Spectroscopy
- Flourometry
- pH and Blood Gas Analysis
- Chloridometry
- Osmometry
- Refractometry
- Gas-Liquid Chromotography
- Electrophoresis
- Scintillation Counters
- Autoanalyzer
- Analytical Balance
- Centrifuges
- Diluters
- Coulter Counter Models, A, B, Fn
- Coulter Counter Model S

*TEXT OR REFERENCE*

Title: MEDICAL AND HOSPITAL CONTROL SYSTEMS: THE CRITICAL DIFFERENCE
Author: David A. Simmons, with 10 contributing authors
Publisher: Little, Brown and Company, Inc.
Medical Division
34 Beacon Street
Boston, MA 02106
Year: 1972
No. of Pages: 739
Cost: $28.50

In this book, the authors show how the hospital can become a more efficient and cost-conscious organization by means of the most advantageous use of equipment and facilities. Control concepts and techniques, along with their application both in hospitals and in the medical profession, are presented and developed. The first major section of the book deals with the concepts behind control systems. The second section covers techniques ranging from basic statistical methods to instrumentation control and cost analysis. The topic of medical instrumentation for both clinical application and research programs is presented in chapters dealing with device evaluation specifications, preventive maintenance and service, calibration and medical product liability. The third section, which is concerned with application of control systems techniques to health care services, emphasizes improvement in patient care and the elimination of inefficient procedures. (Excerpts from publisher review)

*TEXT OR REFERENCE*

Title: MEDICAL EQUIPMENT SERVICE MANUAL — THEORY AND MAINTENANCE PROCEDURES
Author: Frank Biloon
Publisher: Prentice-Hall, Inc.
Englewood Cliffs, NJ 07632
Year: 1978
No. of Pages: 252
Cost: $18.95

This manual describes the following medical equipment:

- Sterilizers
- Diathermy and Microwave Therapy Machines
- Ultrasonic Therapy Machines and Cleaners
- Sine and Galvanic Muscle Stimulators
- Lamps
- Electrosurgical Machines
- Laser Beam and Plasma Jet Surgery Machines
- Electrocardiography and Electrocardioscope Recorders
- Cardiac Care Equipment
- Surgical X-ray Equipment

The book reviews and displays representative types of equipment using photographs and schematics in addition to text. Trouble-shooting methods as well as service checklists are provided in most instances. Additionally, frequently-asked questions concerning the equipment are answered. An introductory chapter addresses the topic of electrical safety in terms of the equipment, the patient and the operator.

*TEXT OR REFERENCE*

Title: MEDICAL INSTRUMENTATION FOR HEALTH CARE
Authors: Leslie Cromwell, M. Arditti, F.J. Weibell, E.A. Pfeiffer, B. Steele, & J.A. Labok
Publisher: Prentice-Hall, Inc.
Englewood Cliffs, NJ 07632
Year: 1976
No. of Pages: 418
Cost: $18.95

*Medical Instrumentation for Health Care* is an introductory guide to biomedical instruments, designed for use by medical, paramedical and technical specialists. Unlike many texts for biomedical equipment technology, this book does not assume any background in electricity and electronics. The first part of the book addresses fundamentals. Included are an overview of medical instrumentation, an introduction to electricity and an explanation of the physiological variables that must be measured. The second part deals with the major clinical applications of biomedical equipment. The topics of electrodes, electrocardiography, indirect and direct measurement of blood pressure, defibrillators and pacemakers, mobile intensive care, and instrumentation in special care units and neonatal care are covered in some depth. Chapters composing the final part cover a wide scope but with less depth. Topics addressed include blood flow and volume, cardiac catherization, the surgical suite, electroencephalography, electromyography, ultrasonics and fetal monitoring. The last three chapters deal with safety in the hospital, computers in medicine, and the care and use of electronic equipment. Appended are a glossary of electrical and instrument terms, a suggested approach to calibration and balancing of an amplifier-transducer system, and problems and exercises.
*TEXT OR REFERENCE*

Title: PRINCIPLES OF APPLIED BIOMEDICAL INSTRUMENTATION
Authors: L.A. Geddes & L.E. Baker
Publisher: John Wiley & Sons
Eastern Distribution Center
1 Wiley Drive
Somerset, NJ 08873
Year: 1975 (Second Edition)
No. of Pages: 616
Cost: $25.25

Designed for use by life or physical scientists, this book presents principles and applications of biomedical instrumentation. The text begins with an introduction to the transduction and measurement of physiological events. This is followed by chapters addressing resistive transducers; inductive transducers, capacitive transducers, photoelectric transducers, piezoelectric transducers, thermoelectric transducers and chemical transducers. Also included are discussions of different types of electrodes and their use in measuring bioelectric events and the detection of physiological events by impedance. Final chapters further deal with bioelectric events, semiconductor transducers and criteria for the faithful reproduction of an event. Extensive use is made of diagrams, figures, photographs and references throughout the text.
*TEXT OR REFERENCE*

Title: THE RESTON ENCYCLOPEDIA OF BIOMEDICAL ENGINEERING TERMS
Authors: Rudolf F. Graf & G.J. Whalen
Publisher: Reston Publishing Company, Inc.
11480 Sunset Hills Road
Reston, VA 22090
Year: 1977
No. of Pages: 415
Cost: $22.95

This book is designed to bridge the gap between medical and engineering terminology by defining biomedical engineering terms in a way that can be understood by both disciplines. The encylcopedia defines a comprehensive set of medical and electronic terms. In addition to terms, common abbreviations and formulas are also presented. It thus can serve as a reference for students and instructors as well as technologists in both the medical and BMET professions.
*TEXT OR REFERENCE*

Title: SERVICING ELECTROCARDIOGRAPHS
Author: Elliot S. Kanter
Publisher: Howard W. Sams & Co., Inc.
4300 West 62nd Street
P.O. Box 558
Indianapolis, IN 46206
Year: 1975
No. of Pages: 224
Cost: $12.95 (Paperback)

This publication discusses the following pieces of biomedical equipment:

- Burdick EK 4 Electrocardiograph
- Burdick EK/5 Electrocardiograph
- Burdick EK/5A Electrocardiograph
- Cambridge VS 4 Electrocardiograph
- Hewlett-Packard Models 1500 B and 1511 B Electrocardiographs
- Profexray EK 100 Electrocardiograph
- Parke-Davis 2100A Electrocardiograph

Detailed circuit descriptions of each of the electrocardiograph models are provided pictorially, schematically and verbally. Additionally, comprehensive troubleshooting and maintenance procedures are outlined. Parts lists and specifications are also included. An overview of basic servicing techniques introduces the book, and a final chapter presents miscellaneous service data.
*TEXT OR REFERENCE*

Title: SERVICING MEDICAL & BIOELECTRONIC EQUIPMENT
Author: Joseph J. Carr
Publisher: TAB Books
Blue Ridge Summit, PA 17214
Year: 1977
No. of Pages: 349
Cost: $10.95 (Hardcover)
$ 8.95 (Paperback)

This book discusses some of the more common medical instrumentation from the point of view of the service technician. Information is provided on the properties, operation and testing of the following medical equipment/instrumentation:

- Electrocardiograph Machines
- Medical Electrodes and Transducers
- Blood Pressure Amplifiers
- Medical Oscilloscopes
- Bedside and Portable Monitors
- ICU/CCU Multibed Monitoring Systems
- Strip Chart Recorders
- Defibrillators and Cardioverters
- Electrosurgical Generators
- Cardiographic and Catheterization Lab Equipment
- Cardiac Radio Telemetry
- Scientific Instruments in Clinical Use
- Ultrasonic Instruments
- Balloon Pumps, Pneumotachometers, and Cardiomemories
- Test Instruments and Repair Facilities
- Electrical Safety
- X-Ray Apparatus
- Lung, Blood Gas, and Dialysis Machines

The presentation assumes some background in electronics, human anatomy and physiology on the part of the reader. A bibliography, a list of medical prefixes, suffixes and roots and a glossary of medical terms are appendicized.
*TEXT OR REFERENCE*

Title: ELECTRONICS AND MEDICAL INSTRUMENTATION SERIES MANUALS
Author: Technical Education Research Centers
Publisher: PASCO Scientific
1933 Republic Avenue
San Leandro, CA 94577
Year: 1975/1976
Cost: $26.00 FOB for complete set

These manuals discuss a series of electronic components which were designed for instruction in BMET. The manuals address the following topics:

1. *Instrument System Series*
   - ECG Monitor
   - Electrocardiograph
   - Cardiotachometer
   - Blood Pressure Recorder
   - Electronic Clinical Thermometer
2. *Operation and Measurement Series*
   - Electrocardiography
   - Blood Pressure Measurement
3. *Basic Circuit Series*
   - Operational Amplifier
   - Power Amplifier
   - Differential Amplifier
   - Voltage Level Detector
   - Monostable Multivibrator
   - Low Pass Filter
   - Unijunction Oscillator
   - Wheatstone Bridge

With the accompanying instrumentation modules, the user is capable of constructing five medical instruments. These are described in the Instrument Series Manuals which also provide pictorials and schematic diagrams of the instruments and experiments in system assembly, calibration and operation. The Operation and Measurement Series provides instruction in measuring blood pressure and heart activity, while the Basic Circuit Series discusses and offers experiments for the eight electronic components.
*TRAINING MANUALS*

Title: TRANSDUCER APPLICATIONS HANDBOOK
Author: Tektronix, Inc.
Publisher: Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97005
Year: 1973
No. of Pages: 73

This handbook offers a brief description of Physical Measurement Instrumentation produced by Tektronix. Also included are practical application examples and selected reference material used in making transducer measurements. Appended are power density graphs for three different resistance values of strain gages and two vibration nomograms. The contents were extracted from *Transducer Measurements* (Chapters 5 & 6, Appendices C & D), which is currently out of print
*TRAINING MANUAL*

Title: THE GUIDE TO BIOMEDICAL STANDARDS
Authors: Allan F. Pacela & B.E. Arnold
Publisher: Quest Publishing Company
P.O. Box 4141
Diamond Bar, CA 91765
Year: 1978-1979 (Sixth Edition)
No. of Pages: 67
Cost: $8.00 (Paperback; published as an annual supplement to The Newsletter of Biomedical Safety and Standards)

"*The Guide to Biomedical Standards* is a directory of U.S., International and other National Standards that control or regulate medical equipment and medical-care facilities. Section I lists these standards as issued by standards-setting bodies in the U.S., arranged alphabetically by organization. Section II lists international standards, and Section III includes selected standards of other countries from Australia through the United Kingdom. Section IV lists the mailing addresses of national standards bodies. Published since 1970, the "Guide" is now in its sixth edition, and has been extensively revised and corrected. Individuals throughout the world have cooperated in the revision of this publication." (Excerpts from authors' preface).
*CODES & STANDARDS*

Title: HEALTH CARE SAFETY-BASIC LIBRARY
Author: National Fire Protection Association
Publisher: National Fire Protection Association
Publications Sales Department
470 Atlantic Avenue
Boston, MA 02210
Stock No.: HCSL-A
Year: 1979
No. of Pages: 1400
Cost: $38.25

This library is a collection of health care standards and codes produced by NFPA. It includes the following:

- NFPA 3M - Health Care Emergency Preparedness
- NFPA 30 - Flammable and Combustible Liquids Code
- NFPA 53M - Hazards in Oxygen-Enriched Atmospheres
- NFPA 56A - Inhalation Anesthetics
- NFPA 56B - Respiratory Therapy
- NFPA 56C - Laboratories in Health-Related Institutions
- NFPA 56F - Non-flammable Medical Gas Systems
- NFPA 70 - National Electric Code
- NFPA 76A - Essential Electrical System
- NFPA 76B-T - Safe Use of Electricity in Patient-Care Facilities
- NFPA 76C - High-Frequency Electrical Equipment in Health Care Facilities
- NFPA 101 - Life Safety Code

*CODES & STANDARDS*

Title: HOSPITAL ELECTRICAL FACILITIES
Author: Noyce L. Griffin
Publisher: U.S. Department of Health, Education, and Welfare
Public Health Service
Health Services and Mental Health Administration
Health Facilities Planning and Construction Services
Office of Architecture and Engineering
Silver Spring, MD 20910
Year: 1969
No. of Pages: 36
Cost: No charge for single copies

"Guidelines for electrical installations for architects and engineers concerned with hospital construction were initially issued in 1949 by the Division of Hospital and Medical Facilities of the Public Health Service and revised in 1952, 1959, 1961, and 1965. In this revision, the guidelines have been rewritten to reflect changes in current practices, to provide up-to-date references to applicable codes and standards, and to conform with recommended design practices that should be followed in the construction of hospital and health facilities. It is hoped that this publication will be useful to architects, engineers, and others concerned with providing optimum hospital electrical system facilities." (Excerpted from Foreword of document)

Though somewhat outdated this publication provides some useful guidelines.

*CODES & STANDARDS*

Title: TECHNIQUES FOR MONITORING PHYSIOLOGICAL PARAMETERS, EDUCATIONAL AND TRAINING PROGRAM
Prepared by: Hewlett-Packard Medical Products Group
Publisher: Hewlett-Packard Company
175 Wyman Street
Waltham, MA 02154
Year: 1978
No. of Pages: Booklet: 52; Audio Visual Package: 353 slides, 4 audio tape cassettes
Cost: Booklet: $5.00 (single copy)
Audio-Visual Package: $300.00

This booklet presents reproductions of slides and narration of a slide/tape presentation of techniques for monitoring ECG, pressure, respiration and temperature. Though designed primarily for an audience of critical care nurses, BMETs are considered a secondary audience. Four independent parts comprise the program and are described by Hewlett-Packard as follows:

- ECG MONITORING — Discusses ECG physiology, preparation for ECG monitoring, typical problems and solutions, plus operating techniques for the HP Models 78203C, 78341 and 78342 Monitors. (37 minutes)
- PRESSURE MONITORING — Treats the physics and tools of liquid pressure measurements; preparation for pressure monitoring, including zeroing and calibration; typical problems and solutions; and techniques for operating the HP Models 78205B/C, 78341 and 78342 Monitors. (39 minutes)
- RESPIRATION MONITORING — Covers the impedance pneumography technique of respiration detection, preparation for repiration monitoring, typical problems and solutions, and how to use the HP Models 7820C, 78212D and 78341 Monitors. (17 minutes)
- TEMPERATURE MONITORING — Discusses the mechanisms of human temperature regulation, preparation for temperature monitoring, some typical problems and solutions, and operating tips for the HP Models 78204C, 78214C, 78341 and 78342 Monitors. (15 minutes)
- PACKAGE CONTENTS: 353 numbered, color-coded 35mm slides covering ECG (133 slides), Pressure (121 slides), Respiratory (56 slides) and Temperature (43 slides) Monitoring; four audio tape cassettes with complete explanative narration and slide-change tones; and one 52-page booklet containing reproductions of all slides and narration text. Program may be used with any 35mm slide projector and audio tape cassette player.

*AUDIO VISUAL/BOOKLET*

# REFERENCES


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Johnson County Community College, Office of Institutional Research. "Employer Manpower Needs and Job Entry Requirements for Biomedical Equipment Technician." In *Special Package of Instructional Resources for Biomedical Equipment Technology.* Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1978.

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Spetz, Sally H., W.D. Heath and D.S. Katz. *Current and Future Employment Opportunities in New and Emerging Occupations Within Illinois.* Raleigh, NC: CONSERVA, Inc., 1978. (Sponsored by the Illinois State Board of Education.)

Technical Education Research Centers. "Biomedical Equipment Technology: A Suggested Postsecondary Curriculum." (1975) In *Special Package of Instructional Resources for Biomedical Equipment Technology.* Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1978.

# APPENDICES

## APPENDIX A

## SCHOOLS CONTACTED WHICH OFFER COURSEWORK IN BIOMEDICAL EQUIPMENT TECHNOLOGY

CALIFORNIA
Kaiser Foundation Hospital
BMET Apprenticeship Program
4747 Sunset Boulevard
Los Angeles, CA 90027

ILLINOIS
Oakton Community College
7900 North Nagle Avenue
Morton Grove, IL 60053

IOWA
United Electronics Institute
1119 Fifth Street
West Des Moines, IA 50265

Western Iowa Tech Community College
4747 Stone Avenue
Sioux City, IA 51102

MARYLAND
Howard Community College
Little Patuxent Parkway
Columbia, MD 21044

MASSACHUSETTS
Springfield Technical Community College
One Armory Square
Springfield, MA 01105

MICHIGAN
Schoolcraft College
18600 Haggerty Road
Livonia, MI 48152

MINNESOTA
Hennepin Technical Center, South Campus
9200 Flying Cloud Drive
Eden Prairie, MN 55344

916 Area Vo-Tech Institute
3300 Century Avenue, North
White Bear Lake, MN 55110

MISSOURI
St. Louis Community College at Forest Park
5600 Oakland
St. Louis, MO 63110

NEW MEXICO
Luna Vocational-Technical Institute
P.O. Box Drawer K
Las Vegas, NM 87701

OKLAHOMA
Tulsa Junior College
909 South Boston
Tulsa, OK 74115

PENNSYLVANIA
Temple University
College of Engineering Technology
12th & Norris Streets
Philadelphia, PA 19122

TEXAS
Amarillo College
P.O. Box 447
Amarillo, TX 79178

St. Phillips College
San Antonio, TX 78203

Texas State Technical Institute
Waco, TX 76705

UTAH
Utah Technical College at Salt Lake
4600 South Redwood Road
Salt Lake City, UT 84107

WASHINGTON
North Seattle Community College
9600 College Way North
Seattle, WA 98103

Spokane Community College
2000 Greene
Spokane, WA 99207

WISCONSIN
Milwaukee Area Technical College
1015 North Sixth Street
Milwaukee, WI 53203

Western Wisconsin Technical Institute
Sixth and Vine Streets
LaCrosse, WI 54601

## APPENDIX B

## INDIVIDUALS INDICATING AN INTEREST IN CONSULTING

Dr. A.F. Adkins
Amarillo College
P.O. Box 447
Amarillo, TX 79178
(806)376-5111

Mr. Ed Babudro
Hennepin Technical Center, South Campus
9200 Flying Cloud Drive
Eden Prairie, MN 55344
(612)944-2222

Mr. Kenneth DuPont
Springfield Technical Community College
One Armory Square
Springfield, MA 01105
(413)781-3508

Mr. Gailord Gordon
Kaiser Foundation Hospital
Apprenticeship Program
4747 Sunset Boulevard
Los Angeles, CA 90027
(213)667-8485

Mr. Phillip Gottlieb
Texas State Technical Institute
Waco, TX 76705
(817)799-3611

Ms. Suzanne Jacobs
Oakton Community College
7900 North Nagle Avenue
Morton Grove, IL 60053
(312)967-5120

Mr. Dave Krall
Milwaukee Area Technical College
1015 North Sixth Street
Milwaukee, WI 53203
(414)278-6316

Mr. Dan Landiss
St. Louis Community College at Forest Park
5600 Oakland
St. Louis, MO 63110
(314)644-9100

Mr. Bruce Reid
Howard Community College
Little Patuxent Parkway
Columbia, MD 21044
(301)992-4866

Mr. Kenneth Schultz
Schoolcraft College
18600 Haggerty Road
Livonia, MI 48152
(313)591-6400

Dr. Victor Schutz
Temple University
College of Engineering Technology
Twelfth and Norris Streets
Philadelphia, PA 19122
(215)787-7820

Mr. Robert B. Tuchel (contact)
Learning Resource Coordinator
916 Area Vo-Tech Institute
3300 Century Avenue North
White Bear Lake, MN 55110
(612)770-2351
(Mr. Gordon Williams, Instructor)

Mr. Richard Wallace
Tulsa Junior College
909 South Boston
Tulsa, OK 74145
(918)587-6561

Mr. Ulrich E. Zeisler
Utah Technical College at Salt Lake
4600 South Redwood Road
Salt Lake City, UT 84107
(801)969-3411

Mr. Bud Zook
United Electronics Institute
1119 Fifth Street
West Des Moines, IA 50265
(515)223-1486

# APPENDIX C

## RELATED AGENCIES/ORGANIZATIONS

Alliance for Engineering in Medicine and Biology
4405 East-West Highway, Suite 404
Bethesda, MD 20014

American Electronics Association
2600 El Camino Real
Palo Alto, CA 94306

American Hospital Association
840 North Lake Shore Drive
Chicago, IL 60611

American Institute of Chemical Engineers
345 East 47th Street
New York, NY 10017

American Society for Engineering Education
One DuPont Circle, Suite 400
Washington, DC 20036

American Society for Quality Control
Biomedical Division
161 West Wisconsin Avenue
Milwaukee, WI 53203

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

Association for the Advancement of Medical Instrumentation
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209

Biomedical Engineering Society
P.O. Box 2399
Culver City, CA 90230

Institute of Electrical and Electronic Engineers
345 East 47th Street
New York, NY 10017

Instrument Society of America
400 Stanwix Street
Pittsburgh, PA 15260

International Society of Certified Electronics Technicians
Medical Electronics Committee
P.O. Box 1258, ISU Station
Ames, IA 50010

Medical Electronics Society
2994 West Liberty Avenue
Pittsburgh, PA 15216
(formerly Medical Electronics and Data Society)

National Academy of Engineering
Committee on the Interplay of Engineering with Biology and Medicine
2101 Constitution Avenue, N.W.
Washington, DC 20418

Society of Biomedical Equipment Technicians
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209

# APPENDIX D

# TASK LISTINGS AND JOB COMPETENCIES


D.1 Task Listing: Biomedical Equipment Technology

D.2 Job Specifications for Bio-Medical Equipment Technician

D.3 Tasks Performed by the BMET

D.4 Employer and Technician Perceptions of Important Skills, Knowledges and Attitudes for Biomedical Equipment Technicians

**Appendix D.1**

**Task Listing: Biomedical Equipment Technology**

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916 Area Vo-Tech Institute,
White Bear Lake, MN, 1972

Student _____

Instructor _____

BIOMEDICAL EQUIPMENT TECHNOLOGY
900-902

| Task # | Avg. Hours | | |
|---|---|---|---|
| 902-102 | ( 4) | _____ | Define the role of the BMET |
| 971-001 | ( 11) | _____ | Review basic mathematical operations |
| 908-200 | ( 3) | _____ | Identify safety practices to be observed in the use of electrical tools and equipment |
| 001 | ( 12) | _____ | Define terms used in the electricity & electronics field, as well as use basic electrical test equipment in the study of matter & electricity |
| 971-002 | ( 20) | _____ | Use basic algebraic equations |
| 908-002 | ( 8) | _____ | Utilize soldering irons in the soldering of components & wires |
| 971-003 | ( 20) | _____ | Set up and solve algebraic equations |
| 040 | ( 10) | _____ | Perform calculations using powers of ten, scientific notation, metric prefixes & significant figures |
| 125 | ( 10) | _____ | Work with metric units |
| 908-003 | ( 30) | _____ | Solve simple electrical circuits by applying Ohm's Law |
| 004 | ( 18) | _____ | Use conductors, insulators, resistors, fuses & circuit breakers |
| 005 | ( 30) | _____ | Use Ohm's Law in solving for resistance, voltages, currents & wattages in series, parallel & series-parallel electrical circuits |
| 971-028 | ( 12) | _____ | Solve factoring problems |
| 029 | ( 15) | _____ | Work with algebraic fractions |
| 908-006 | ( 60) | _____ | Solve DC resistive circuits using Kirchoff's Laws |
| 007 | ( 30) | _____ | Solve basic linear electrical circuits using network theorem analysis |
| 971-006 | ( 8) | _____ | Ohm's Law and series circuits |
| 009 | ( 14) | _____ | Ohm's Law applied to parallel circuits |
| 908-008 | ( 18) | _____ | Construct & use DC ammeters, voltmeters, ohmmeters & multimeters |
| 010 | ( 16) | _____ | Use permanent magnets, electromagnets, relays & generators in basic electrical circuits |
| 971-008 | ( 24) | _____ | Solve fractional algebraic equations |
| 015 | ( 12) | _____ | Calculate voltage dividers |
| 013 | ( 18) | _____ | Calculate problems containing exponents & radicals |
| 908-011 | ( 24) | _____ | Observe AC waveforms, calculate time periods, frequencies & wave lengths, as well as measure & calculate AC voltages |
| 971-016 | ( 20) | _____ | Solve problems using trigonometry |
| 017 | ( 17) | _____ | Apply trig to solution of right triangles |
| 908-012 | ( 12) | _____ | Use the oscilloscope to measure voltages, frequencies & wave lengths, as well as observe wave shapes |
| 971-018 | ( 15) | _____ | Solve plane vector combinations |
| 908-013 | ( 30) | _____ | Use inductance principles to solve circuit variables for inductors, inductive reactance & transformers |
| 971-019 | ( 15) | _____ | Periodic functions |
| 908-014 | ( 18) | _____ | Utilize capacitance principles to solve circuit variables for capacitors & capacitive reactance |
| 971-020 | ( 11) | _____ | Fundamental ideas of AC |



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Student _____

Biomedical Equipment Technology (900-902) - continued

| Task # | Avg. Hours | | |
|---|---|---|---|
| 908-017 | ( 18) | _____ | Measure & calculate RC and RL circuit characteristics & time constants |
| 018 | ( 18) | _____ | Measure currents & voltages in AC circuits containing resistance, inductance & capacitance |
| 971-021 | ( 16) | _____ | Calculate various parameters of AC series circuits |
| 022 | ( 16) | _____ | Calculate various parameters of AC parallel & series-parallel circuits |
| 023 | ( 12) | _____ | Use phasor algebra in the solution of AC circuit problems |
| 908-019 | ( 24) | _____ | Construct resonant circuits & measure the resonant effect of tuned circuits |
| 902-104 | ( 4) | _____ | Introduction to the man-instrument system |
| 110 | ( 4) | _____ | Shop safety procedures, Phase I |
| 120 | ( 6) | _____ | Basic Wheatstone Bridge operation |
| 908-030 | ( 60) | _____ | Use simple semi-conductor diodes in basic circuits |
| 031 | ( 30) | _____ | Measure simple transistor circuit characteristics |
| 032 | ( 48) | _____ | Measure common base, common emitter & common collector transistor circuit characteristics |
| 035 | ( 18) | _____ | Construct & use transistor characteristic curves & load lines, as well as calculate transistor gains & observe outputs of Class A, B and C amplifiers |
| 037 | ( 18) | _____ | Measure bias in bias stabilization circuits |
| 038 | ( 24) | _____ | Measure the results of various transistor coupling networks |
| 971-036 | ( 20) | _____ | Solve problems involving decibels & logarithmic ratios of current & voltage |
| 908-039 | ( 18) | _____ | Measure single ended power amplifier characteristics |
| 040 | ( 18) | _____ | Measure basic phase splitter, phase inverter & push-pull amplifier circuit characteristics |
| 050 | ( 24) | _____ | Measure transistor, oscillator and multivibrator characteristics |
| 052 | ( 18) | _____ | Construct & measure the characteristics of power supplies & transistor power supply regulators |
| 075 | ( 18) | _____ | Construct & measure field effect transistor circuits |
| 078 | ( 18) | _____ | Measure special semi-conductor diode characteristics |
| 080 | ( 24) | _____ | Measure four layer & unijunction device characteristics |
| 083 | ( 20) | _____ | Introduction to ICs |
| 902-192 | ( 12) | _____ | Oscilloscope principles, operation & maintenance |
| 126 | ( 6) | _____ | Basic unijunction oscillator operation |
| 132 | ( 12) | _____ | Basics of operational amplifiers |
| 122 | ( 12) | _____ | Basic power amplifier operation |
| 128 | ( 12) | _____ | Basic voltage level detector operation |
| 902-124 | ( 6) | _____ | Monostable multivibrators |
| 108 | ( 6) | _____ | Low-pass filter |
| 130 | ( 12) | _____ | Basic differential amp operation |
| 904-095 | ( 10) | _____ | Examine basic vacuum tube theory & operation |
| 979-001 | ( 8) | _____ | Prepare a resume |
| 904-097 | ( 10) | _____ | Analyze characteristics of a triode vacuum tube |
| 979-002 | ( 2) | _____ | Analyze your on-the-job attitudes & employer-employee relationships |
| 904-099 | ( 10) | _____ | Analyze tetrodes, pentodes & other special purpose vacuum tubes |



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Student _____

Biomedical Equipment Technology (900-902) - continued

| Task # | Avg. Hours | | |
|---|---|---|---|
| 979-005 | ( 2) | _____ | Complete an application blank |
| 904-102 | ( 10) | _____ | Analyze the characteristics & operation of transistor & vacuum tube oscillators |
| 979-008 | ( 8) | _____ | Participate in a mock job interview |
| 904-103 | ( 10) | _____ | Identify the different types of interstage coupling used in amplifiers |
| 979-020 | ( 1) | _____ | Investigate the course content of the work attitudes program for Tech Lab students |
| 904-104 | ( 4) | _____ | Analyze the theory & application of audio frequency amplifiers |
| 979-021 | ( 2) | _____ | Recognize verbal and non-verbal communication techniques |
| 904-106 | ( 10) | _____ | Investigate the theory & design characteristics of radio frequency (RF) amplifiers |
| 979-022 | ( 5) | _____ | Investigate your perception & listening skills |
| 904-109 | ( 10) | _____ | Explore the aspects of basic transmitters |
| 979-023 | ( 8) | _____ | Investigate feedback skills to assist in the development of positive job attitudes |
| 904-111 | ( 10) | _____ | Investigate amplitude modulation & transmitter principles |
| 979-024 | ( 5) | _____ | Investigate your value system & how it affects your job performance |
| 904-115 | ( 10) | _____ | Analyze the theory & operation of demodulation & basic receiving principles |
| 902-140 | ( 40) | _____ | Terminology relating to the body |
| 904-117 | ( 10) | _____ | Analyze the basic concepts of heterodyning & intermediate frequency (IF) amplifiers |
| 902-142 | ( 6) | _____ | Principles of hospital organization |
| 904-119 | ( 10) | _____ | Examine & construct a basic circuitry for developing a local CW signal & a converter (mixer) stage |
| 902-150 | ( 40) | _____ | Basic human anatomy & physiology, Phase I |
| 901-316 | ( 12) | _____ | Add & subtract numbers in binary & other base systems |
| 904-121 | ( 10) | _____ | Investigate the theory & operation of frequency modulation |
| 902-152 | ( 40) | _____ | Basic human anatomy & physiology, Phase II |
| 901-318 | ( 18) | _____ | Wire & verify by means of truth tables the input & output circuitry of logic |
| 904-123 | ( 10) | _____ | Analyze an antenna system |
| 902-160 | ( 18) | _____ | Analysis of human physiological parameters |
| 904-125 | ( 4) | _____ | Investigate the design & construction of public address systems & intercom systems |
| 127 | ( 4) | _____ | Explore the operation & characteristics of the audio tape recorder |
| 902-170 | ( 30) | _____ | Shop operation, preventative maintenance & record keeping |
| 901-322 | ( 18) | _____ | Write Boolean equations corresponding to logic diagrams & wire the logic to correspond to a Boolean equation |
| 901-324 | ( 18) | _____ | Construct arithmetic logic |
| 902-180 | ( 24) | _____ | Identify environmental safety procedures & uses of test equipment used in health care facilities |
| 190 | ( 30) | _____ | Develop procedures for troubleshooting principles & practices |



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Student _____

Biomedical Equipment Technology (900-902) - continued

| Task # | Avg. Hours | | |
|---|---|---|---|
| 901-326 | ( 18) | _____ | Construct flip-flop registers & counters on the Logi-Tran Two & verify the operations |
| 328 | ( 18) | _____ | Wire & check special logic codes & error detecting systems |
| 902-194 | ( 12) | _____ | Battery analysis |
| 196 | ( 36) | _____ | Principles & applications of transducers & electrodes |
| 206 | ( 6) | _____ | Principles of blood pressure measurement, indirect methods |
| 208 | ( 9) | _____ | Principles of blood flow metering devices |
| 210 | ( 6) | _____ | Principles of ECG operation & measurement |
| 212 | ( 35) | _____ | Principles of blood pressure measurement, direct methods |
| 214 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of an electroencephalograph (EEG) to manufacturer's specifications & end user requirements |
| 220 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of telemetry monitoring devices |
| 230 | ( 40) | _____ | Basic cardiac measurements |
| 234 | ( 30) | _____ | Perform preventative maintenance, troubleshooting & repair of individual patient monitoring stripchart devices |
| 236 | ( 40) | _____ | Perform preventative maintenance, troubleshooting & repair of individual patient monitoring scope devices |
| 238 | ( 24) | _____ | Perform preventative maintenance, troubleshooting & repair of modular monitoring devices |
| 239 | ( 20) | _____ | Special project: _____ |
| 240 | ( 40) | _____ | Perform preventative maintenance, troubleshooting & repair of combined modular patient monitoring devices |
| 242 | ( 30) | _____ | Perform preventative maintenance, troubleshooting & repair of defibrillators/cardioverters |
| 246 | ( 20) | _____ | Special project as assigned by instructor |
| 250 | ( 6) | _____ | Perform preventative maintenance, troubleshooting & repair of dye injectors and infusion pumps |
| 260 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of diathermy devices |
| 262 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of ultrasonographic devices |
| 264 | ( 6) | _____ | Perform preventative maintenance, troubleshooting & repair of therapeutic lamp devices |
| 266 | ( 6) | _____ | Perform preventative maintenance, troubleshooting & repair of muscle stimulators |
| 268 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of ultrasonic cleaning devices |
| 270 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of electro-surgical devices |
| 272 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of ultrasonic monitor |
| 979-076 | ( 8) | _____ | Technical report writing |
| 902-412 | ( 30) | _____ | Identify the nature and uses of various clinical laboratory devices |
| 973-011 | ( 4) | _____ | Operate balances in the chemical laboratory |



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Student _____

Biomedical Equipment Technology (900-902) - continued

| Task # | Avg. Hours | | |
|---|---|---|---|
| 973-310 | ( 6) | _____ | Identify & perform the operation & maintenance of a constant temperature bath |
| 312 | ( 10) | _____ | Identify & perform the opration & maintenance of the Ab[illegible] 3-L refractometer |
| 314 | ( 10) | _____ | Identify the basic types of radioactive materials, radioactivity counters & exposure devices; operate & perform maintenance on the equipment |
| 316 | ( 10) | _____ | Operate & troubleshoot pH meter |
| 318 | ( 18) | _____ | Identify & perform the operation & maintenance of the spectrophotometer |
| 320 | ( 12) | _____ | Identify & perform the operation & maintenance of the infrared spectrophotometer |
| 322 | ( 12) | _____ | Operate & maintain a gas chromatograph |
| 324 | ( 18) | _____ | Identify & perform the operation & maintenance of the atomic absorption spectrophotometer |
| 902-558 | ( 30) | _____ | Identify fundamental principles of microprocessing |
| 560 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of diagnostic pulmonary devices |
| 562 | ( 18) | _____ | Perform preventative maintenance, troubleshooting & repair of therapeutic pulmonary devices |
| 580 | ( 24) | _____ | Identify fundamentals of radiation & radioactivity |
| 610 | ( 12) | _____ | Identify fundamental characteristics of microbiology |
| 620 | ( 24) | _____ | Perform preventative maintenance, troubleshooting & repair of sterilizing devices |
| 630 | ( 12) | _____ | Determine methods, principles & practices used in sterile environments |
| 640 | ( 20) | _____ | Professional development: _____ |
| 642 | ( 20) | _____ | Professional development: _____ |
| 644 | ( 20) | _____ | Professional development: _____ |
| 646 | ( 20) | _____ | Professional development: _____ |
| 648 | ( 20) | _____ | Professional development: _____ |
| 650 | ( 20) | _____ | Professional development: _____ |
| 921 | (120) | _____ | Internship |

| Date | Institute Name | Location |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

OPTIONAL TASKS: (170 hours of optional tasks are necessary to satisfy graduation requirements.)

| | | | |
|---|---|---|---|
| 901-125 | ( 18) | _____ | Construct a basic electrical circuit for control of fluid power |
| 126 | ( 18) | _____ | Construct a circuit for continuous air cylinder reciprocation |
| 127 | ( 18) | _____ | Construct an air circuit using a time delay relay |



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Student _____

Biomedical Equipment Technology (900-902) - continued

| Task # | Avg. Hours | | (Optional Tasks - continued) |
|---|---|---|---|
| 901-128 | ( 18) | _____ | Construct photoelectric circuits, cylinder dwell circuits, peck drilling circuits, & safety circuits |
| 140 | ( 15) | _____ | Digital control measuring |
| 141 | ( 15) | _____ | Digital control servo |
| 142 | ( 15) | _____ | Digital control electro-hydraulic |
| 902-172 | ( 12) | _____ | Investigate sources of rules and regulations |
| 174 | ( 12) | _____ | Develop a method of utilizing rules and regulations |
| 184 | ( 12) | _____ | Identify methods & practices used in instrument calibration |
| 204 | ( 12) | _____ | Principles of the clinical electronic thermometer |
| 232 | ( 12) | _____ | Perform preventative maintenance, troubleshooting & repair of the cardiotachometer |
| 235 | ( 20) | _____ | Special Project: _____ |
| 237 | ( 20) | _____ | Special Project: _____ |
| 350 | ( 30) | _____ | FCC preparation - Elements I and II |
| 352 | ( 30) | _____ | FCC preparation - Elements III and IV |
| 244 | ( 6) | _____ | Perform preventative maintenance, troubleshooting and repair of pacemakers |
| 258 | ( 20) | _____ | Special project: _____ |
| 413 | ( 20) | _____ | Special project: _____ |
| 570 | ( 24) | _____ | Perform preventative maintenance, troubleshooting and repair of dental equipment |
| 590 | ( 12) | _____ | Perform preventative maintenance, troubleshooting and repair of infant incubator |
| 592 | ( 30) | _____ | Perform preventative maintenance, troubleshooting and repair of paging devices |
| 602 | ( 6) | _____ | Perform preventative maintenance, troubleshooting and repair of hypo-hyperthermia devices |
| 604 | ( 12) | _____ | Perform preventative maintenance, troubleshooting and repair of operating room devices |
| 606 | ( 12) | _____ | Perform preventative maintenance, troubleshooting and repair of suction and pressure systems and/or devices |
| 971-012 | ( 13) | _____ | Simultaneous equations |
| 011 | ( 12) | _____ | Graph linear equations |
| 014 | ( 14) | _____ | Solve quadratic equations |
| 039 | ( 15) | _____ | Graphical analysis |
| 005 | ( 15) | _____ | Use units and dimensions |



TOTAL NUMBER OF HOURS FOR PROGRAM - 2,780

11/1/77 ms

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## Appendix D.2

## Job Specifications for Bio-Medical Equipment Technician

Derived by Texas State Technical Institute
Waco, TX

**Job Specifications for Bio-Medical Equipment Technician**

- Communicates with and provides technical assistance to medical staff using standard medical terminology related to instrumentation and his/her work.
- Reads and interprets instructional and maintenance manuals as well as blue prints, mechanical drawings and schematic diagrams related to the equipment upon which he performs services.
- Reads technical journals and literature related to the job field.
- Returns to the manufacturer malfunctioning equipment, in or out of warranty, that is not repairable within the facility.
- Cleans and/or lubricates mechanical instruments and devices associated with medical apparatus.
- Initiates requests for replacement parts and materials.
- Uses common hand tools as required in the performance of job tasks, such as soldering iron, pliers, screwdriver, wire cutters, etc.
- Operates fundamental machine tools such as hand drills, drill presses, bench grinder/buffers, breaks, shears, etc.
- Removes and replaces all external components on single function instruments such as control knobs, fuses, circuit breakers and meters.
- Repairs pan and patient scales.
- Performs preventive maintenance, as required, on elements, tubing, gaskets and glassware in water stills, auto-analyzers, constant temperature devices and dental units.
- Performs preventive maintenance on steam valves, thermostats, heating elements, regulators and gaskets found on portable autoclaves and sterilizers.
- Performs preventive maintenance and performance checks on respirator components such as oil-less pumps, valves, filters, pressure switches, gaskets, hoses, clamps and bellows.
- Works with fluid and gas fittings and tubing such as those found in respiration equipment and cooling and heating equipment; e.g., solders, swages, cuts, bends, etc.
- Tests thermostats such as those found in water baths, air warmers, etc.
- Inspects line cords and line connectors that are worn or damaged on all medical equipment.
- Solders standard electrical and electronic components.
- Repairs and makes performance checks on equipment such as incubator ovens, heating elements, bacterial water baths, tissue water baths, and water and blood temperature regulators.
- Repairs and makes performance checks on heating elements and thermal controls of infant incubators.
- Makes performance checks on patient electrode cables such as those used for ECG, external pacemakers, defibrillators, electrosurgical equipment and impadence pneumographs.
- Aligns visible and ultra-violet light sources in spectrometers.
- Performs preventive maintenance, repairs and performance checks on suction and circulating pumps of all types including pump drive belts, regulators, filters and diaphragms.
- Performs preventive maintenance, repairs and performance checks on clinical centrifuge and other small motor driven device components such as rotors, sample holders, motor brushes, motor bearings, drive couplings and shaft seals.
- Performs preventive maintenance and repairs on fractional horsepower electrical motors from such apparatus as pumps, fraction cloolectors, centrifuges, shakers, electrical beds and surgical tables.
- Provides preventive maintenance of equipment such as incubator ovens, heating elements, bacterial water baths, tissue water baths, and water and blood temperature regulators.
- Operates basic test equipment, such as high- and low-voltage power supplies, multimeters, oscilloscopes, tube and transistor testers, and bridges.
- Measures parameters, such as voltage, current, resistance, capacitance and inductance.
- Tests diodes, vacuum tubes and transistors.
- Removes and replaces standard electronic components from all types of single function equipment such as defibrillators and electrocardiographs.
- Assembles simple electrical, mechanical and optical subassemblies, such as photodetector circuits, indicators, single stage amplifiers and power supplies.
- Breadboards simple electrical, mechanical and optical systems.
- Troubleshoots and repairs simple circuits such as series and parallel resistive circuits as found in examining lamps, blowers, heaters, etc.
- Verifies operational characteristics of new instrumentation against manufacturer specifications upon which he normally performs service.
- Modifies instrumentation as directed.
- Performs preventive maintenance on, repairs, and cleans atomizer gas burners of flamephotometers.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on high speed air drills and dental drills.
- Lays-out and fabricates sheet metal such as electronic chassis, front panels and cabinets.
- Performs preventive maintenance, troubleshoots, repairs, and makes performance checks on instruments such as colorimeters and densitometers.
- Inspects and installs electrical grounds (to eliminate ground loops) to metallic objects in patient areas.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on temperature- and pressure-regulated equipment such as autoclaves, sterilizers, refrigerated water baths, spectrophotometer purging systems and refrigerated centrifuges.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on single function emergency instruments such as basic infant incubators and resuscitators.
- Performs preventive maintenance, removes and replaces, and repairs X-ray film processor components such as relays, rollers, switches, thermostats, blowers and timers.
- Operates test equipment such as high- and low-frequency signal generators; low-frequency, dual-channel and high frequency oscilloscopes; sweep generators; slide wire bridges; strip chart and x-y recorders, and event counters.
- Measures electrical parameters such as sinosoidal wave forms, frequency, bandwidth, gain, attenuation, phase, periods, and inductive and capacitive reactance using standard test equipment.
- Troubleshoots, repairs and makes performance checks on passive electronic circuits such as low, high and band pass filters, resonant circuits, etc.
- Troubleshoots, repairs and makes performance checks on active electronic circuits such as D-C amplifiers, differential amplifiers, operational amplifiers, power supplies, silicon-controlled rectifier assemblies, multivibrators and switching circuits.
- Troubleshoots and repairs basic electronic circuits and subassemblies such as filters, transformers, rectifiers, regulators, tubes and transistors.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on chemical analysis instrumentation such as pH meters, electrophoresis apparatus and titrators.

- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on physiological monitors such as electrocardiographs, electroencephalographs and electromyographs including their recorders.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on electronic particle counters such as Coulter counters.
- Troubleshoots, repairs and calibrates single-loop servomechanisms such as those found in a potentiometric recorder.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on test equipment such as VOM's galvanometers, bridges, signal generators, x-y and strip chart recorders, digital counters and oscilloscopes.
- Establishes and maintains inventory of spare parts, tools and materials.
- Maintains records of location and condition of electronic test equipment.
- Secures and maintains files of manufacturers' operating and repair service manuals.
- Identifies and maintains files of instrument parts, tools and material distributors.
- Plans and schedules all work assignments.
- Verifies performance of outside servicemen working on warranteed or contracted equipment or the installation of new equipment when required.
- Organizes repair facility such as placement of benches, test equipment and utilities.
- Develops and directs preventive maintenance program.
- Instructs others in the operation of instruments over which he has responsibility.
- Evaluates medical instrumentation and advises medical staff, upon requests, on the acquisition of medical instrumentation.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on multiple-function emergency instruments such as cardioverters and external pacemakers.
- Performs preventive maintenance, troubleshoots, repairs and makes performance checks on complex physiological systems such as ICU, CCU and OR apparatus.
- Selects, retrieves and returns to files manufacturers' operating and repair service manuals.
- Maintains log and records of each work assignment.

**Appendix D.3**

**Tasks Performed by the BMET**

Derived by Technical Education
Research Centers, Cambridge, MA

In *Special Package of Instructional Resources for Biomedical Equipment Technology*
Columbus, OH: The Ohio State University,
The National Center for Research
in Vocational Education

## TASKS PERFORMED BY THE BMET
## IN DECREASING ORDER OF PRIORITY
**(correlated with developed units/modules)**

JOB FAMILY: Biomedical Equipment Technician and Related Occupations

EXIT LEVEL: Technician (entry)

| *TASKS PERFORMED BY BMET | UNITS/MODULES OF INSTRUCTION (Denver Public Schools) |
|---|---|
| 1. (2105) Reads and interprets instructional and maintenance manuals as well as blue prints, mechanical drawings, and schematic diagrams related to the equipment upon which they perform services. | • Use of manufacturer's repair service manuals<br>• Using NFPA pamphlets |
| 2. (2104) Communicates with and provides technical assistance to medical staff using standard medical terminology related to instrumentation and their work. | • Communications with medical professionals, technicians and associations<br>• Medical terminology |
| 3. (2302) Removes and replaces components of pipette dryers, ultrasonic cleaners, etc. | |
| 4. (2420) Preventive maintenance of equipmet such as incubator ovens, heating elements, bacterial water baths, tissue water baths, and water and blood temperature regulators. | • Unit VII. Preventive Maintenance Procedures and Practices (2 modules) |
| 5. (2501) Operates basic test equipment, such as high and low voltage power supplies, multimeters, oscilloscopes, tube and transistor testers and bridges. | • Operating principals-test devices |
| 6. (2502) Measures parameters, such as voltage, current, resistance, capacitance and inductance. | • Unit VI. Performing Operational Checks and Troubleshooting Biomedical Equipment |
| 7. (2503) Tests diodes, vacuum tubes and transistors. | • Unit VI |
| 8. (2304) Removes and replaces line cords and line connectors that are worn or damaged on all medical equipment. | • Unit VII. Preventive Maintenance Procedures and Practices (2 modules) |

*Reference: Interim Report III Task Analysis by Selected Criteria: A Manual Development of Career Opportunities for Biomedical Equipment Technicians. Technical Education Research Center (TERC), Boston, Massachusetts.

| TASKS PERFORMED BY BMET | UNITS/MODULES OF INSTRUCTION (Denver Public Schools) |
|---|---|
| 9. (2107) Participates in organized education and training activities to upgrade knowledge and job performance. | • Occupational overview.<br>• Occupational responsibilities. |
| 10. (2109) Cleans and/or lubricates mechanical instruments and devices associated with medical apparatus. | • Unit VII. Preventive Maintenance Procedures and Practices (2 modules) |
| 11. (2213) Performance checks—respirator components such as oil-less pumps, valves, filters, pressure switches, gaskets, hoses, clamps and bellows. | • Unit VI. Performing Operational Checks and Troubleshooting Biomedical Equipment (6 modules) |
| 12. (2217) Works with fluid and gas fittings and tubing such as those found in respiration equipment and cooling and heating equipment, e.g., solders, swages, cuts, bands, etc. | • Unit III. Fundamentals of Control Systems (5 modules) |
| 13. (2504) Removes and replaces and operates standard electronic components from all types of single function equipment such as defibrillators and electrocardiographs. | • Unit V. Removal and Replacement Procedures for Standard/Electrical/Mechanical Components (2 modules) |
| 14. (2101) Selects, retrieves, and returns to files manufacturers operating and repair service manuals. | • Use of manufacturer's operating and repair service manual. |
| 15. (2102) Transports equipment to in-house repair facility according to established procedures. | |
| 16. (2103) Maintains log and records of each work assignment. | |
| 17. (2110) Initiates requests for replacement parts and materials. | |
| 18. (2201) Uses common hand tools as required in the performance of job tasks. | • Continuous |
| 19. (2202) Operates fundamental machine tools such as hand drills, drill presses, bench grinders/buffers, breaks, shears, etc. | • Continuous |
| 20. (2203) Removes and replaces all external components on single function instruments such as control knobs, fuses, circuit breakers and meters. | • Unit III. Fundamentals of Control Systems<br>• Unit V. Removal and Replacement Procedures for Standard Elec/Mach. Components (2 modules) |

| TASKS PERFORMED BY BMET | UNITS/MODULES OF INSTRUCTION (Denver Public Schools) |
|---|---|
| 21. (2401) Solders standard electrical and electronic components. | Previous experiences/concepts course and electronic fundamentals. |
| 22. (2108) Returns malfunctioning equipment, in or out of warranty, that is not repairable within the facility to the manufacturer. | |
| 23. (2211) Preventive maintenance—respirator components such as oil-less pumps, valves, filters, pressure switches, gaskets, hoses, clamps and bellows. | • Unit VII. Biomedical Equipment Preventive Maintenance Procedures (2 modules) |
| 24. (2301) Tests thermostats such as those found in water baths, air warmers, etc. | • Unit X. Repairing Biomedical Equipment Systems (11 modules) |
| 25. (2216) Repairs refrigeration components such as start relays, condenser packs, coolant seals and thermostats. | • Unit X. Repairing Biomedical Equipment Systems (11 modules) |
| 26. (2303) Inspects line cords and line connectors that are worn or damaged on all medical equipment. | • Unit VII. Biomedical Equipment Preventive Maintenance (2 modules) |
| 27. (2505) Assembles simple electrical, mechanical, and optical subassemblies, such as photodetector circuits, indicators, single stage amplifiers and power supplies. | |
| 28. (2106) Reads technical journals and literature related to the job field. | • Unit I. Introduction to Biomedical Field (8 modules) |
| 29. (2206) Removes and replaces as required, elements, tubing, gaskets, and glassware in water stills, auto-analyzers, constant temperature devices and dental units. | • Unit X. Repairing Biomedical Equipment Systems (11 modules) |
| 30. (2209) Preventive maintenance—valves, regulators and seals on gas sterilizers. | • Unit VII. Preventive Maintenance Procedures and Practices |
| 31. (2214) Preventive maintenance—instrument refrigeration components such as start relays, condenser packs, coolant seals and thermostats. | • Unit VII. Preventive Maintenance Procedures |
| 32. Performs safety instructions. | • Environmental Safety<br>• Unit IV. Safety Inspections (4 modules) |
| 33. Interpersonal relations. | • Human Relations<br>• Occupational Survival Skills |

**Appendix D.4**

**Employer and Technician Perceptions of Important Skills, Knowledges and Attitudes for Biomedical Equipment Technicians**

Derived by Johnson County Community College,
Office of Institutional Research,
Overland Park, KS, 1976

In *Special Package of Instructional Resources for Biomedical Equipment Technology*.
Columbus, OH: The Ohio State University,
The National Center for Research in
Vocational Education, 1978

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**

| Skill to be Acquired: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| Measure electrical parameters such as sinosoidual waveforms, frequency, bandwidth, gain, attenuation, phase, period, and inductive and capacitive reactance using standard test | | | | | |
| Technician | 70% | 25% | 5% | 0% | 0% |
| Employer | 60 | 27 | 10 | 0 | 3 |
| Combined | 64 | 26 | 8 | 0 | 2 |
| Perform simple operations on machine tools (e.g., lathes, mills, drill presses, bench grinders, and hand drills) | | | | | |
| Technician | 15 | 25 | 30 | 25 | 5 |
| Employer | 10 | 3 | 57 | 27 | 3 |
| Combined | 12 | 12 | 46 | 26 | 4 |
| Operate test equipment such as high and low frequency signal generators; low frequency, dual channel, and high frequency oscilloscopes; sweep generators; universal bridges; strip charts and X-Y recorders | | | | | |
| Technician | 80 | 20 | 0 | 0 | 0 |
| Employer | 64 | 13 | 20 | 0 | 3 |
| Combined | 70 | 16 | 12 | 0 | 2 |
| Lay out and fabricate electronic devices that include cabinet layout and printed circuit board wiring or chassis wiring | | | | | |
| Technician | 0 | 25 | 70 | 0 | 5 |
| Employer | 7 | 13 | 60 | 13 | 7 |
| Combined | 4 | 18 | 64 | 8 | 6 |
| Read and interpret instructional and maintenance manuals as well as blue prints, mechanical drawings, and schematic diagrams related to the equipment serviced | | | | | |
| Technician | 95 | 5 | 0 | 0 | 0 |
| Employer | 77 | 16 | 7 | 0 | 0 |
| Combined | 84 | 12 | 4 | 0 | 0 |
| Communicate with and provide technical assistance to medical staff using standard medical terminology related to instrumentation | | | | | |
| Technician | 50 | 40 | 10 | 0 | 0 |
| Employer | 47 | 27 | 20 | 6 | 0 |
| Combined | 48 | 32 | 16 | 4 | 0 |
| Clean and/or lubricate mechanical instruments and devices associated with medical apparatus | | | | | |
| Technician | 35 | 35 | 30 | 0 | 0 |
| Employer | 40 | 10 | 43 | 7 | 0 |
| Combined | 38 | 20 | 38 | 4 | 0 |
| Solder standard electrical and electronic components on printed circuit boards and hand wired circuits | | | | | |
| Technician | 70 | 25 | 5 | 0 | 0 |
| Employer | 70 | 13 | 13 | 0 | 4 |
| Combined | 70 | 18 | 10 | 0 | 2 |
| Use common hand tools such as needlenose pliers, diagonal cutters and screw drivers in the performance of job tasks | | | | | |
| Technician | 95 | 5 | 0 | 0 | 0 |
| Employer | 73 | 23 | 4 | 0 | 0 |
| Combined | 82 | 16 | 2 | 0 | 0 |
| Evaluate medical instrumentation and advise medical staff on the relative merits of potential acquisitions | | | | | |
| Technician | 30 | 25 | 35 | 10 | 0 |
| Employer | 33 | 30 | 24 | 10 | 3 |
| Combined | 32 | 28 | 28 | 10 | 2 |

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**
(continued)

| Skill to be Acquired: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| Collect and analyze data obtained from analog, special purpose, and standard digital computers | | | | | |
| Technician | 10% | 5% | 60% | 25% | 0% |
| Employer | 10 | 14 | 60 | 6 | 10 |
| Combined | 10 | 10 | 60 | 14 | 6 |
| Develop digital systems that include counters, digital to analog converters as well as circuits for interfacing medical instrumentation to standard and special purpose digital computers | | | | | |
| Technician | 5 | 5 | 60 | 20 | 10 |
| Employer | 0 | 7 | 67 | 13 | 13 |
| Combined | 2 | 6 | 64 | 16 | 12 |
| Develop special electronic circuits and instrumentation as required by medical or engineering staff | | | | | |
| Technician | 5 | 25 | 50 | 15 | 5 |
| Employer | 0 | 17 | 56 | 17 | 10 |
| Combined | 2 | 20 | 54 | 16 | 8 |
| Prepare tables, charts, and graphs for technical reports and communications | | | | | |
| Technician | 30 | 10 | 45 | 10 | 5 |
| Employer | 13 | 20 | 50 | 10 | 7 |
| Combined | 20 | 16 | 48 | 10 | 6 |
| Perform spot and routine safety checks on equipment including ground and leakage current checks | | | | | |
| Technician | 95 | 5 | 0 | 0 | 0 |
| Employer | 80 | 10 | 3 | 3 | 4 |
| Combined | 86 | 8 | 2 | 2 | 2 |

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**
(continued)

| Possess a Working Knowledge of: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| Blood-gas analyzer | | | | | |
| Operation | | | | | |
| Technician | 50% | 15% | 35% | 0% | 0% |
| Employer | 40 | 3 | 40 | 0 | 17 |
| Combined | 44 | 8 | 38 | 0 | 10 |
| Preventive Maintenance | | | | | |
| Technician | 50 | 20 | 30 | 0 | 0 |
| Employer | 44 | 6 | 37 | 0 | 13 |
| Combined | 46 | 12 | 34 | 0 | 8 |
| Repair | | | | | |
| Technician | 55 | 5 | 40 | 0 | 0 |
| Employer | 34 | 6 | 47 | 0 | 13 |
| Combined | 42 | 6 | 44 | 0 | 8 |
| Cardiac Monitor | | | | | |
| Operation | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 56 | 17 | 20 | 0 | 7 |
| Combined | 68 | 12 | 16 | 0 | 4 |
| Preventive Maintenance | | | | | |
| Technician | 80 | 10 | 10 | 0 | 0 |
| Employer | 53 | 23 | 17 | 0 | 7 |
| Combined | 64 | 18 | 14 | 0 | 4 |
| Repair | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 43 | 20 | 30 | 0 | 7 |
| Combined | 60 | 14 | 22 | 0 | 4 |
| EKG Equipment | | | | | |
| Operation | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 56 | 13 | 24 | 0 | 7 |
| Combined | 68 | 10 | 18 | 0 | 4 |
| Preventive Maintenance | | | | | |
| Technician | 80 | 10 | 10 | 0 | 0 |
| Employer | 50 | 30 | 13 | 0 | 7 |
| Combined | 62 | 22 | 12 | 0 | 4 |
| Repair | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 43 | 20 | 30 | 0 | 7 |
| Combined | 60 | 14 | 22 | 0 | 4 |
| Defibrillator | | | | | |
| Operation | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 56 | 13 | 24 | 0 | 7 |
| Combined | 68 | 10 | 18 | 0 | 4 |
| Preventive Maintenance | | | | | |
| Technician | 80 | 10 | 10 | 0 | 0 |
| Employer | 50 | 26 | 17 | 0 | 7 |
| Combined | 62 | 20 | 14 | 0 | 4 |
| Repair | | | | | |
| Technician | 85 | 5 | 10 | 0 | 0 |
| Employer | 40 | 20 | 33 | 0 | 7 |
| Combined | 58 | 14 | 24 | 0 | 4 |

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**
(continued)

| Possess a Working Knowledge of: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| Monitor Alarm Systems | | | | | |
| Operation | | | | | |
| Technician | 85% | 5% | 10% | 0% | 0% |
| Employer | 47 | 23 | 20 | 0 | 10 |
| Combined | 62 | 16 | 16 | 0 | 6 |
| Preventive Maintenance | | | | | |
| Technician | 80 | 10 | 10 | 0 | 0 |
| Employer | 43 | 30 | 17 | 0 | 10 |
| Combined | 58 | 22 | 14 | 0 | 6 |
| Repair | | | | | |
| Technician | 75 | 15 | 10 | 0 | 0 |
| Employer | 40 | 20 | 30 | 0 | 10 |
| Combined | 54 | 18 | 22 | 0 | 6 |
| Respirators | | | | | |
| Operation | | | | | |
| Technician | 50 | 15 | 35 | 0 | 0 |
| Employer | 40 | 10 | 30 | 0 | 20 |
| Combined | 44 | 12 | 32 | 0 | 12 |
| Preventive Maintenance | | | | | |
| Technician | 45 | 15 | 40 | 0 | 0 |
| Employer | 36 | 17 | 27 | 0 | 20 |
| Combined | 40 | 16 | 32 | 0 | 12 |
| Repair | | | | | |
| Technician | 45 | 15 | 40 | 0 | 0 |
| Employer | 27 | 10 | 43 | 0 | 20 |
| Combined | 34 | 12 | 42 | 0 | 12 |
| Infant Incubators | | | | | |
| Operation | | | | | |
| Technician | 55 | 10 | 25 | 0 | 10 |
| Employer | 33 | 14 | 36 | 0 | 17 |
| Combined | 42 | 12 | 32 | 0 | 14 |
| Preventive Maintenance | | | | | |
| Technician | 55 | 10 | 25 | 0 | 10 |
| Employer | 30 | 23 | 33 | 0 | 14 |
| Combined | 40 | 18 | 30 | 0 | 12 |
| Repair | | | | | |
| Technician | 55 | 10 | 25 | 0 | 10 |
| Employer | 20 | 16 | 50 | 0 | 14 |
| Combined | 34 | 14 | 40 | 0 | 12 |
| Spectrophotemeter | | | | | |
| Operation | | | | | |
| Technician | 35 | 30 | 35 | 0 | 0 |
| Employer | 30 | 10 | 43 | 3 | 14 |
| Combined | 32 | 18 | 40 | 2 | 8 |
| Preventive Maintenance | | | | | |
| Technician | 30 | 35 | 30 | 0 | 5 |
| Employer | 27 | 17 | 46 | 0 | 10 |
| Combined | 28 | 24 | 40 | 0 | 8 |
| Repair | | | | | |
| Technician | 25 | 40 | 35 | 0 | 0 |
| Employer | 17 | 14 | 53 | 6 | 10 |
| Combined | 20 | 24 | 46 | 4 | 6 |

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**
(continued)

| Possess a Working Knowledge of: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| X-Ray Equipment | | | | | |
| Operation | | | | | |
| Technician | 35% | 10% | 40% | 10% | 5% |
| Employer | 27 | 10 | 43 | 3 | 17 |
| Combined | 30 | 10 | 42 | 6 | 12 |
| Preventive Maintenance | | | | | |
| Technician | 25 | 10 | 45 | 10 | 10 |
| Employer | 17 | 26 | 40 | 3 | 14 |
| Combined | 20 | 20 | 42 | 6 | 12 |
| Repair | | | | | |
| Technician | 20 | 10 | 50 | 10 | 10 |
| Employer | 14 | 16 | 43 | 14 | 13 |
| Combined | 16 | 14 | 46 | 12 | 12 |
| Communication Systems | | | | | |
| Operation | | | | | |
| Technician | 45 | 10 | 25 | 5 | 15 |
| Employer | 20 | 20 | 36 | 10 | 14 |
| Combined | 30 | 16 | 32 | 8 | 14 |
| Preventive Maintenance | | | | | |
| Technician | 35 | 15 | 30 | 5 | 15 |
| Employer | 14 | 33 | 33 | 10 | 10 |
| Combined | 22 | 26 | 32 | 8 | 12 |
| Repair | | | | | |
| Technician | 40 | 5 | 35 | 5 | 15 |
| Employer | 10 | 23 | 43 | 14 | 10 |
| Combined | 22 | 16 | 40 | 10 | 12 |
| Other (e.g., Polygraphs, dental equipment, etc.) | | | | | |
| Operation | | | | | |
| Technician | 50 | 19 | 31 | 0 | 0 |
| Employer | 29 | 6 | 36 | 29 | 0 |
| Combined | 40 | 12 | 33 | 15 | 0 |
| Preventive Maintenance | | | | | |
| Technician | 57 | 7 | 36 | 0 | 0 |
| Employer | 12 | 12 | 41 | 35 | 0 |
| Combined | 32 | 10 | 39 | 19 | 0 |
| Repair | | | | | |
| Technician | 57 | 7 | 36 | 0 | 0 |
| Employer | 6 | 59 | 0 | 35 | 0 |
| Combined | 29 | 3 | 49 | 19 | 0 |

## EMPLOYER AND TECHNICIAN PERCEPTIONS OF IMPORTANT SKILLS, KNOWLEDGE AND ATTITUDES FOR BIOMEDICAL EQUIPMENT TECHNICIANS

**Spring 1976**
(continued)

| Knowledge of and Ability to: | Essential | Very Important | Desirable | Not Important | Not Applicable |
|---|---|---|---|---|---|
| Effectively coordinate work with the work of others who are working as a team | | | | | |
| Technician | 80% | 15% | 5% | 0% | 0% |
| Employer | 52 | 29 | 19 | 0 | 0 |
| Combined | 63 | 23 | 14 | 0 | 0 |
| Research and review technical reports | | | | | |
| Technician | 40 | 30 | 20 | 10 | 0 |
| Employer | 27 | 20 | 43 | 10 | 0 |
| Combined | 32 | 24 | 34 | 10 | 0 |
| Make good judgments regarding repair techniques best suited to any given problem | | | | | |
| Technician | 65 | 20 | 15 | 0 | 0 |
| Employer | 63 | 24 | 13 | 0 | 0 |
| Combined | 64 | 22 | 14 | 0 | 0 |
| Predict potential equipment problems | | | | | |
| Technician | 30 | 40 | 30 | 0 | 0 |
| Employer | 40 | 33 | 27 | 0 | 0 |
| Combined | 36 | 36 | 28 | 0 | 0 |
| Meet high quality standards of neatness and accuracy | | | | | |
| Technician | 50 | 40 | 10 | 0 | 0 |
| Employer | 58 | 32 | 10 | 0 | 0 |
| Combined | 55 | 35 | 10 | 0 | 0 |
| Meet deadlines consistently | | | | | |
| Technician | 55 | 30 | 15 | 0 | 0 |
| Employer | 43 | 50 | 7 | 0 | 0 |
| Combined | 48 | 42 | 10 | 0 | 0 |

## APPENDIX E

# CERTIFICATION OF BIOMEDICAL EQUIPMENT TECHNICIANS

### GENERAL INFORMATION

The Board of Examiners for Biomedical Equipment Technicians, operating under the Certification Commission, maintains a certification program for biomedical equipment technicians (BMETs).* The objective of this national certification program is to identify broadly competent persons capable of performing a wide variety of tasks in the field of biomedical equipment technology. The program provides the opportunity for BMETs to be formally recognized as persons who have demonstrated certain knowledge of the overall field of biomedical equipment technology.

The Certification Commision, whose membership includes prestigious groups relating to health care, supervises the certification of biomedical equipment technicians as well as that of clinical engineers. The current members (August 1978) of the Certification Commission are:

American Association of Gynecologic Laparoscopists
American Association of Physicists in Medicine
American College of Cardiology
American College of Chest Physicians
American Heart Association
Association for the Advancement of Medical Instrumentation
Canadian Medical and Biological Engineering Society
Clinical Engineering Association of New Jersey
Joint Commission on the Accreditation of Hospitals
National Society of Professional Engineers
Indian Health Service, Public Health Service
Pharmaceutical Manufacturers Association
Society of Biomedical Equipment Technicians
Veterans Administration

### ELIGIBILITY

Eligibility for taking the certification examination requires satisfaction of at least *one* of these three criteria: (1) Two years' BMET experience and an associate's degree in BMET, (2) Four years' BMET experience, or (3) Three years' BMET experience and an associate's degree in electronics. An applicant need not be currently employed as a BMET.

Applicants who do not have the associate's degree, but who feel they have either comparable or higher education, may submit official transcripts and a written request for special consideration.

### FEE

The application fee is $50.00. Of this fee, $30.00 is a non-refundable service charge to cover the cost of processing the application. If the applicant is determined ineligible for the certification examination, $20.00 of the application fee will be refunded.

### EXAMINATION SITES

The examination is given at least four times each year in major cities determined by geographic distribution of applicants eligible for examination. Applicants will be notified of examination dates and sites after determination of eligibility. Anyone failing the examination may reapply for certification and may thus repeat the examination after one year from the date of the failed examination.

### EXAMINATION FORMAT

The examination contains 150 multiple-choice questions and two essay questions. These are the five main categories of the multiple-choice questions and the number in each category:

| | |
|---|---|
| Anatomy and physiology | 20 questions |
| Electric and electronic fundamentals | 40 questions |
| Medical-equipment function and operation | 30 questions |
| Safety in health-care facilities | 25 questions |
| Medical-equipment troubleshooting | 35 questions |

The essay questions require relatively subjective responses on topics such as personnel relations, disposition of unsafe equipment, and scheduling of preventive maintenance.

* According to the definition set by AAMI several years ago, the biomedical equipment technician is a person knowledgeable about the theory of operation, the underlying physiologic principles, and the practical, safe clinical application of biomedical equipment. His or her capabilities may include installation, calibration, inspection, preventive maintenance, and repair of general biomedical and related technical equipment, as well as operation or supervision of equipment-control, safety, and maintenance programs and systems.

## EXAMINATION SCORING

The test is graded on a pass-fail basis, with 70% the minimum passing *overall* score; and 50% the minimum score per subject area. Thoughtful essays can contribute to the total score as much as 5% of the person's score on the multiple-choice section of the examination.

## EXAMINATION TIME AND AIDS

The typical examinee takes approximately 6 hours to complete the examination, although 8 hours are allotted. The examinee can bring an electronic calculator or a slide rule and one 3-inch by 5-inch card showing *only mathematic equations*. Both sides of the card may bear equations.

## BIBLIOGRAPHY

The "reference books" recommended by a special committee of certified biomedical equipment technicians (CBETs) on the Board of Examiners are:


*Physiology*

1. McClintic, J. R.: BASIC ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY, Wiley & Sons, New York, 1975.
*2. Tokay, Elbert: FUNDAMENTALS OF PHYSIOLOGY, Barnes and Noble, Inc., Scranton, PA, 1972.

*Electronics and Instrumentation*

*1. Boylestad, R. and Nashelsky, L.: ELECTRICITY, ELECTRONICS, AND ELECTROMAGNETICS, Prentice-Hall, Englewood Cliffs, New Jersey, 1977.
2. Cooper, W. D.: ELECTRONIC INSTRUMENTATION AND MEASUREMENT TECHNIQUES, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, 1978.
3. Ewing, Galen W.: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS, Fourth Edition, McGraw-Hill Book Co., New York, 1975.

*Biomedical Apparatus*

*1. Cromwell and others: BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1973.
2. Geddes, L. A. and Baker, L. E.: PRINCIPLES OF BIOMEDICAL INSTRUMENTATION, Second Edition, John Wiley & Sons, Inc., New York, 1975.
*3. Strong, Peter: BIOPHYSICAL MEASUREMENTS, Tektronix, Inc., Beaverton, Oregon, 1970.

*Medical Terminology*

* Smith, G. L. and Davis, P. E.: MEDICAL TERMINOLOGY, Second Edition, John Wiley and Sons, Inc., New York, 1969.

*Safety*

*1. Pertinent sections of books listed under the category of biomedical apparatus, above; and
*2. Pertinent manuals, standards, and guidelines published by organizations such as the National Fire Protection Association (NFPA), Association for the Advancement of Medical Instrumentation (AAMI), Underwriters Laboratories (UL), and the Joint Commission for Accreditation of Hospitals (JCAH). Although the Board realizes that these documents do not in themselves have the force of law, and that some of them are controversial, it feels that the BMET should be fully aware of their content and their relation to the work of a BMET.


*Items denoted by an asterisk ( * ) are strongly recommended.


**CERTIFICATION COMMISSION**
1901 N. Ft. Myer Drive, Suite 602
Arlington, Virginia 22209
703 — 525-4890

# APPLICATION FOR CERTIFICATION

**BOARD OF EXAMINERS FOR BIOMEDICAL EQUIPMENT TECHNICIANS (BMET)**
1901 N. Ft. Myer Drive, Suite 602, Arlington, Virginia 22209
703 — 525-4890

**INSTRUCTIONS:**

The information you give in this application, the opinions received from your references, and the results of your certification test will form the basis for judging your eligibility for certification as a biomedical equipment technician (BMET). You should therefore fill out this application carefully and completely. Following the instructions at the top of page 3 of this application, list all your job experiences that are in any way related to biomedical equipment technology. In describing your duties do not give generalizations such as "did engineering drawing" or "was an electronics technician." Give specific descriptions—for example: "repaired equipment in all areas of medical center" or "serviced medical electronic equipment in cardiovascular research laboratory." Indicate the degree to which you were (or are) personally responsible in each position. You may attach supplementary material such as government forms, letters of recognition, and awards to support your application. You should request that transcript(s) be sent promptly to the Certification Commission by each college and technical institute you have attended.

The description below outlines the role and responsibilities of the BMET. Review this job description to insure that your position and functions are those of a BMET as defined by the Certification Commission.

> "A biomedical equipment technician (BMET) is an individual who is knowledgeable about the theory of operation, the underlying physiologic principles, and the practical, safe clinical application of biomedical equipment. His or her capabilities may include installation, calibration, inspection, preventive maintenance, and repair of general biomedical and related technical equipment. He might also be involved in operation or supervision of equipment control, safety and maintenance programs and systems."

Complete this specialty profile by indicating the percentage of your work-time devoted to each category of equipment:

| Equipment type | Percentage of your work-time |
|---|---|
| 1. X-ray | _____ |
| 2. Nuclear Medicine | _____ |
| 3. Cardiovascular | _____ |
| 4. Pulmonary | _____ |
| 5. Anesthesia | _____ |
| 6. Clinical Laboratory | _____ |
| 7. Physical Therapy & Orthopedic Equip. | _____ |
| 8. Other (please specify) | _____ |

Applicant's Name (type or print) _____
Show as you desire on certificate

Office use only:

Application received _____
Fee received _____
Application number _____

*(Please type or print all information carefully)*

## PERSONAL

Name _____ Date of Birth _____
(month day year age)

Telephone Number _____
(home)

Home Address _____
(street city state ZIP CODE)

Present Employer _____

Telephone Number _____
(office)

Employer's Address _____
(street city state ZIP CODE)

Address mail to (check one) ☐ Home Address ☐ Business Address

Present position _____ Department _____
(title)

Immediate supervisor's name and title _____

Are you certified with the Veterans' Administration? _____

## EDUCATION

| Name of School | Complete Address | Course or Program | Dates of Attendance From | To | Diploma or Degree |
|---|---|---|---|---|---|
| High School | | | | | |
| Technical Institute* | | | | | |
| College* | | | | | |
| Other | | | | | |
| | | | | | |
| | | | | | |

*Please have the school(s) send official transcript(s) promptly to the Certification Commission.

## REFERENCES

List five health care professionals* who have knowledge of your combined work experience, especially within the past five years. Specify at least one physician who is in charge of medical or surgical service. List any certified BMET well acquainted with your work.

| Name | Telephone Number | Complete Address | Position |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

*Physicians, clinical engineers, hospital administrators, or other persons in responsible positions in the health care community.

NOTE: Start with your most recent employment and account for each year since high school.

| Dates | | | Give in sequence and detail for each position: (a) Name and location of employer, (b) Title of your position, (c) Name and title of your immediate supervisor, (d) Description of duties (be factual and specific). Supplementary material such as government forms may be attached in support of, but not in lieu of filling out this form. |
|---|---|---|---|
| From Mo. Yr. | To Mo. Yr. | Total Time Yrs. Mos. | |
| | | | |

| Dates | | | |
|---|---|---|---|
| From Mo. Yr. | To Mo. Yr. | Total Time Yrs. Mos | |
| | | | (Attach additional sheets if needed) |

My check for $50.00 is enclosed. (U.S. money only)

I certify that all information herein is correct. I understand that any misrepresentation may result in rejection of this application or the revocation of any certificate issued as a result of this application. I am also aware that any certification I may receive from the Certification Commission will not constitute and shall not be construed as a license. I authorize and release from all liability the Certification Board to make any inquiries that are necessary in ascertaining my eligibility for certification.

Signature Date

# SAMPLE EXAMINATION QUESTIONS

**Anatomy and Physiology**

(The biomedical equipment technician must be able to communicate intelligently with the physician and other hospital staff members. Also, in order to fulfill his responsibilities in the area of safety, calibration and related areas, he must have a reasonable knowledge of anatomy and physiology. The knowledge should include familiarity with terminology and body functions.) *Sample question:*

In fresh, normal human blood, the volume of cells is what part of the total volume?

a. 25%
b. 45%
c. 80%
d. 90%

**Basic Electricity and Electronics**

(Fundamental to many areas of the BMET's function is an in-depth knowledge of basic electricity—not to the engineering depth but certainly including an understanding of current and voltage relationships in both d-c and a-c circuits and the ability to apply fundamental mathematic formulas to circuitry problems.) *Sample question:*

At 600 Hz, the reactance of a 0.1μF capacitor is

a. 2,650 ohms
b. 2.65 kilohms.
c. 15.9 kilohms.
d. 26.5 kilohms.

(Knowledge of solid-state devices is certainly important. The BMET must know semiconductor theory and principles as well as solid-state circuitry. He should know concepts such as biasing, input impedance, and feedback.) *Sample question:*

The formula for AC current gain of a transistor in common-emitter configuration is

a. $\Delta I_C/\Delta I_B$ with $V_{CE}$ constant.
b. $\Delta I_C/\Delta I_E$ with $V_{CB}$ constant.
c. $\Delta I_C/_\beta$ with $I_B$ constant.
d. $\Delta I_E/\Delta I_B$ with $V_{BE}$ constant.

(Although solid-state devices have replaced most electron-tubes, the use of the electron-tube still dictates the need for the respective knowledge. The BMET should understand the function of various types of electron-tubes, photomultipliers, and related items as well as the circuitry associated with power supplies, amplifiers, oscillators, and control circuits.) *Sample question:*

In an amplifier with a triode in common-cathode configuration featuring a purely resistive load, the control-grid voltage and the plate voltage are:

a. in phase
b. not related
c. 90° out of phase
d. 180° out of phase

**Safety in Health-Care Facilities**

(This area includes all aspects of safety relating to: (1) conductivity of floors in operating rooms; (2) flammability of gases used in the medical environment; (3) radiation safety; (4) leakage currents; and (5) pressure safety devices such as those on sterilizers.) *Sample question:*

Which one of the following anesthetic agents is considered the most flammable?

a. Halothane
b. Cyclopropane
c. Nitrous oxide
d. Trichloroethylene

**Medical Instrumentation: Principles and Application**

(The BMET should possess broad knowledge of equipment and instrumentation used in the medical environment. His knowledge should include the theory of operation, clinical application, and unique safety requirments relating to items such as: (1) coronary care systems; (2) spectrophotometers, colorimeters, and related instruments, (3) suction and pressure units; (4) anesthesia machines, respirators, and other gas equipment; (5) diathermy, ultraviolet units; (6) X-ray equipment; and (7) sterilizers.) *Sample questions:*

A sphygmomanometer is used for

a. urinalysis.
b. measuring blood pressure.
c. measuring respiration rate.
d. high-speed counting of erythrocytes.

The paper-speed (chart-speed) usually selected for clinical electrocardiography is

a. 15 millimeters per second.
b. 25 millimeters per second.
c. 50 millimeters per second.
d. 10 centimeters per second.

**Medical Equipment Troubleshooting**

(The BMET must be able to perform theoretical troubleshooting using schematics ranging from one for the simple, serologic water bath to one for an electrocardiograph. Foldout schematics are provided.) *Sample question:*

The operator complains of a-c interference in *all* lead positions. See the foldout schematic No. 6. (not provided for this guide).This trouble could be caused by

a. Zener diode CR1 shorted.
b. K-1 relay not energizing.
c. An "A" deck of S-1 common open.
d. The "D" deck of S-1 shorted to the chassis.

# APPENDIX F

# A SUGGESTED CURRICULUM FOR A TWO-YEAR ASSOCIATE DEGREE PROGRAM

**Society of**
**Biomedical Equipment Technicians**

| *Semester 1* | Credits |
|---|---|
| BMET Orientation | 1 |
| DC and AC Circuits | 4 |
| Technical Mathematics 1 | 4 |
| Fabrication Techniques (shop skills) | 2 |
| Communication Skills 1 | 3 |
| Psychology of Human Relations | 4 |
| | 18 |
| *Semester 2* | |
| Electronic Principles and Circuits 1 | 4 |
| Technical Mathematics 2 | 4 |
| Communication Skills 2 | 3 |
| NFPA Codes and Electrical Safety | 2 |
| Physics for the Health Sciences | 4 |
| | 17 |

| *Semester 3* | Credits |
|---|---|
| Electronic Principles and Circuits 2 | 4 |
| Biomedical Instrumentation 1 | 4 |
| Biomedical Technician Internship 1 | 3 |
| Anatomy and Physiology for the BMET | 3 |
| American Institutions | 3 |
| | 17 |
| *Semester 4* | |
| Electronic Principles and Circuits 3 | 3 |
| Digital Control Systems | 3 |
| Biomedical Instrumentation 2 | 4 |
| Biomedical Technician Internship 2 | 3 |
| American Economy | 3 |
| Microprocessors | 3 |
| | 19 |

John H. Judkins, Chairman
Education Committee of the SBET

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# APPENDIX G
# EQUIPMENT LISTS AND INVENTORIES


G.1 Spokane Community College

G.2 Howard Community College

G.3 Western Wisconsin Technical Institute

G.4 Denver Public Schools

G.5 TERC Equipment Listing

## Appendix G.1

### BMET Equipment at Spokane Community College

List provided by
Harry S. Peden, BMET Instructor

1. Digital Voltmeters
2. Analog Voltmeters
3. Chart Recorders
4. Dual-Trace Oscilloscopes
5. Wheatstone Bridge
6. Impedance Bridge
7. Function Generators
8. Dual Power Supplies
9. High Current, Low Voltage Power Supplies
10. Volt-Ohm-Meter
11. ECG Simulators
12. ECG Analyzer
13. Defibrillator Analyzer
14. Safety Analyzer
15. Storage Oscilloscope

Need for medical equipment is obvious. However, the individual school's financial status will determine what is realistic and, also, the availability of health care training programs will have bearing on the extent of medical instrumentation within the BMET Program. At SCC, as most everywhere else, it is not feasible to purchase medical equipment and so we have incorporated a clinical experience to provide most of the "hands-on" experience. We try to incorporate field trips to medical facilities and technical films throughout the program to get as much exposure to the various instrumentation systems as possible.

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## Appendix G.2

### BMET Equipment at Howard Community College

List provided by
Bruce Reid, BMET Professor

Bird Mark 8 Respirator
Bennent PR-2 Respirator
Ohio Heidbrink Anesthesia Kin-o-meter
Gomco Thermotic Drainage Pump
IVAC IV Infusion Pump
Air Shields Isolette
HP Patient Monitoring Equipment
- Heart Rate
- Blood Pressure
- Temperature Respiration
- Telemetry
- Patient Selector
- ECG Recorders
- Defibrillator
- Pacemaker

Medtronic Pacemaker
Burdick ECG
Cardiac Simulator
Surgistat
Defibrillator Energy Meter
Electrosurgical Analyzer
Safety Analyzers
Doptone Fetal Pulse Detector
Neonatal Monitor (Tektronix)
Various Equipment Donated by Hospitals

## Appendix G.3

### BMET Equipment at Western Wisconsin Technical Institute

In Welch, William G. *Biomedical Electronics Monograph.* LaCrosse, WI: Western Wisconsin Technical Institute, Center for State Vocational, Technical and Adult Education District No. 2, pp. C-3, C-4.

*Located in K311B*

A. 2 - Narco Bio Systems Physiograph Systems
   1 - Hewlett Packard Viso 100 ECG Machine
   1 - Nucleus Radiation Spectrometer
   2 - Bio-Tek Leakage Current Test Sets
   1 - Beckman Model H pH Meter
   1 - Heath Instrumentation Lab

B. Miscellaneous Pieces of Equipment for Troubleshooting and Demonstration
   - Kiron — Zero Reference Flowmeter
   - Fisher — Electrophotometer II
   - B & L — Photometer
   - M Ray Dialysate System
   - Chart Recorders Systems
   - Amplifiers
   - Power Supplies
   - Dia-Therme

C. Equipment Budgeted for or on Order
   1 - Multiple Photometry System
   1 - Spectro Durometer
   1 - Gas Chromatograph
   1 - Storage Oscilloscope
   1 - Spectrophotometer
   2 - Transducer Kits
   3 - Lab Module Kits
   1 - Physiological Monitor
   1 - Oscilloscope with Transducer Measuring System

*Equipment Used Jointly*
*With Medical Lab Technology Program*

*K407*

Coleman 21 Flame Photometer
Coleman Jr. II Visible Spectrophotometer
Dissecting Equipment
Glassware

Other Health Occupation programs have equipment available for demonstration and familarization; these are mainly EEG, ECG, X-Ray, Dental and laboratory equipment.

## Appendix G.4

## BMET Equipment at Denver Public Schools

In *Special Package of Instructional Materials for Biomedical Equipment Technology*. Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1978.

1. Sterilizer, Surgical Dressing with Mfg. Service Manuals & Schematics

   Wilmont Castle Co.
   1777 E. Henrietta Road
   Rochester, NY 14623
   (716)271-6060

   Vernitron Medical Products, Inc.
   Five Empire Boulevard
   Carlstadt, NJ 07072
   (201)641-5500

2. Dental Operating Units with Mfg. Service Manuals & Schematics

   Den-Tal-EZ
   1201 S.E. Diehl
   Des Moines, IA 50315

   Airmaster Dental Unit
   S S White
   Dental Health Products
   Community Drive
   Great Neck, NY 11021

   A-Dec
   Box 111
   Newburg, OR 97132

3. Dental Chair with Mfg. Service Manuals & Schematics

   S S White
   Dental Health Products
   Community Drive
   Great Neck, NY 11021

   Den-Tal-EZ Mfg. Co.
   1201 S.E. Diehl
   Des Moines, IA 50315

   Ritter Co.
   P.O. Box 285
   Rochester, NY 14603

4. Centrifuge with Mfg. Service Manuals & Schematics

   International Equipment Mfg. Co.
   300 Second Avenue
   Needham Hights, MA

   Vernitron Medical Products, Inc.
   Five Empire Boulevard
   Carlstadt, NJ 07072

5. Incubator Infant with Mfg. Service Manuals & Schematics

   Ohio Medical Products
   3030 Airco Drive
   P.O. Box 7550
   Madison, WI 53707

   Puritan-Bennett Corp.
   13th and Oak
   Kansas City, MO 64106

   Air Shields
   330 Jacksonville Road
   Hatboro, PA 19040

6. Electrocardiograph with Mfg. Service Manuals & Schematics

   Hewlett-Packard
   Medical Electronics Division
   175 Wyman Street
   Waltham, MA 02154

   Burdick Corp.
   15 Plumb Street
   Milton, WI 53563

   Birtcher Corp.
   4371 Valley Boulevard
   Los Angeles, CA 90032

   Marquette Electronics, Inc.
   8200 West Tower Avenue
   Milwaukee, WI 53223

7. Cardiac Monitor with Mfg. Service Manuals & Schematics

   Hewlett Packard
   Medical Electronics Division
   175 Wyman Street
   Waltham, MA 02154

   Burdick Corp.
   15 Plumb Street
   Milton, WI 53563

   Abbott Medical Electronics
   8330 Broadway
   P.O. Box 12696
   Houston, TX 77017

   Siemens Corporation
   186 Wood Avenue South
   Iselin, NJ 08830

8. Electrosurgical Apparatus with Mfg. Service Manuals & Schematics

   Valley Lab
   Boulder, CO

9. Defibrillator with Mfg. Service Manuals & Schematics

   Hewlett Packard
   Medical Electronics Division
   175 Wyman Street
   Waltham, MA 02154

   Burdick Corp.
   15 Plumb Street
   Milton, WI 53563

10. Heart Simulator with Mfg. Service Manuals & Schematics

    Instrutek, Inc.
    15 Lincoln Park Center
    Annapolis, MD 21401

    Burdick Corp.
    15 Plumb Street
    Milton, WI 53563

11. Difibrillator Tester with Mfg. Service Manuals & Schematics

    Neurodyne-Dempsey, Inc.
    2505 Oak Street
    Napa, CA 94558

    Bio-Tek Instruments
    Shelburne, VT 05482

12. Conductivity Tester with Mfg. Service Manuals & Schematics
    Bio-Design, Inc.
    43 Canton Street
    Stoughton, MA 02072
    Bio-Tek Instruments
    Shelburne, VT 05482
    Instrutek, Inc.
    15 Lincoln Park Center
    Annapolis, MD 21401
13. Safety Analyzer with Mfg. Service Manuals and Schematics
    Neurodyne-Dempsey, Inc.
    2505 Oak Street
    Napa, CA 94558
    Bio-Tek Instruments
    Shelburne, VT 05482
14. Electrosurgical Output Analyzer with Mfg. Service Manuals & Schematics
    Neurodyne-Dempsey, Inc.
    2505 Oak Street
    Napa, CA 94558
    Bio-Tek Instruments
    Shelburne, VT 05482
15. Photoelectronic Tachometer with Mfg. Service Manuals & Schematics
    Clay Adams
    Division of Dickinson and Co.
    Parsippany, NJ 07054
16. Oxygen Analyzer with Mfg. Service Manuals & Schematics
    Ohio Medical Products
    3030 Airco Drive
    P.O. Box 7550
    Madison, WI 53707
    Foregger Hospital Equip.
    P.O. Box 538
    Allentown, PA 18105
17. Megohmmeter with Mfg. Service Manuals & Schematics
    Instrutek
    15 Lincoln Park Center
    Annapolis, MD 21401
18. Ground Voltage Monitor with Mfg. Service Manuals & Schematics
    Instrutek
    15 Lincoln Park Center
    Annapolis, MD 21401

*Local Purchase Items*

19. Electric Benches
20. Study Carrels
21. Safety Glass Cabinet (with glasses)
22. Electronic Aid Modular System & Associated Test Equipment
23. Vacuum Gage
24. Pressure and Vacuum Gages 0 to 30
25. Oxygen Limiter
26. Low Pressure Regulator
27. High Pressure Regulator
28. Tools With Nonferrous Wrenches
29. Pumps, Hydraulic & Air Compressor
30. Temperature Calibration Unit
31. Calibration Resistor
32. Sterilizer Test Strips
33. Oscilloscope
34. Air Compressor
    Air Techniques, Inc.
35. Line Isolation Monitor with Mfg. Service Manuals & Schematics
    Instrutek
    15 Lincoln Park Center
    Annapolis, MD 21401
36. Line Isolation Alarm with Mfg. Service Manuals & Schematics
    Instrutek
    15 Lincoln Park Center
    Annapolis, MD 21401
37. Line Black Box Tester (120 ohm resistor plug in) with Mfg. Service Manuals and Schematics
    Instrutek
    15 Lincoln Park Center
    Annapolis, MD 21401
38. Surgical Disposal Clothing
    a. Cap
    b. Gown
    c. Booties
    d. Gloves
    e. Trousers
    f. Face Protector
39. Mock-up Operating Table With Conductive Castors
40. Conductive Rubber Covering For Table
41. Conductive Floor Tile

## Appendix G.5

### Technical Education Research Centers
### Equipment Listing

In *Special Package of Instructional Resources for Biomedical Equipment Technology*. Columbus, OH: The Ohio State University, The National Center for Research in Vocational Education, 1978.

The following list summarizes equipment now being used by a successful BMET program and is presented for consideration by schools planning a BMET program.

1. *General Laboratory Equipment*
   - 4 Chalkboards
   - 1 Bulletin board
   - 6 Storage cabinets and parts bin
   - 10 Storage shelves
   - 1 Hose rack
   - 1 Stock cart
   - 20 Tote Trays
   - 12 Work benches
   - 2 File cabinet-legal size
   - 4 File cabinet-letter size
   - 2 File cabinet-overhead projections
   - 2 Storage cabinet-audio cassettes
   - 2 Storage cabinet-35mm slides
   - 1 Cart-projection equipment
   - 10 Projectors-35mm slide
   - 10 Audio cassette players
   - 2 Audio cassette recorder
   - 1 Reader, microfisch
   - 1 Projector, Super 9 cartridge
   - 1 Camera, 35mm single lens reflex
   - 1 Projector, overhead, transparency

2. *Medical Instrumentation for Physiological Measurements*
   - 2 Physiograph, general purpose, 4 channel
   - 1 Electroencephalograph, 8 channel
   - 10 Electrocardiograph, direct writer
   - 4 Simulator, electronic heart
   - 2 Phono-cardiograph

3. *Medical Instrumentation for Intensive Care Monitoring*
   - 2 Defibrillator, D.C. with cardio verter
   - 2 Pacemaker, cardiac, external
   - 2 Pacemaker, cardiac, internal
   - 2 Test set, cardiac monitoring
   - 5 Monitor, bedside, cardiac with scope

4. *Medical Instrumentation for Radiology*
   - 1 Machine, X-ray, diagnostic-complete with table
   - 1 Dental X-ray machine
   - 1 Portable X-ray machine
   - 5 Electronic X-ray simulators
   - 1 Scintillation scanner for radio isotopes
   - 1 X-ray image intensifier
   - 1 Radiation detector, ionization chamber
   - 1 Radiation Detector, "Cutie Pie"

5. *Medical Instrumentation for Clinical Laboratories*
   - 1 Collector, fraction
   - 4 Meter, pH
   - 2 Balance, top loading
   - 2 Cell counter
   - 1 Titrator, spectrophotometric
   - 2 Centrifuge
   - 1 Pippetor, automatic
   - 1 Blood gas apparatus
   - 4 Spectrophotometer
   - 1 Flame photometer
   - 1 Automatic absorption spectrophotometer
   - 1 Falling mercury polarograph
   - 2 Colorimeter
   - 2 Stirring hot plate
   - 2 Dilutor, automatic

6. *Medical Instrumentation for Surgical Suite*
   - 1 Surgical operating light
   - 1 Surgical operating table
   - 1 Isolated electrical power supply, complete with ground fault detectors and line isolation monitors and associated alarms
   - 1 Bio microscope for eye and ear surgery
   - 1 Electro surgical unit
   - 1 Anesthesia machine

7. *Medical Instrumentation for General and Miscellaneous Purposes*
   - 1 Incubator, infant
   - 1 Ultra sonic therapy unit
   - 1 Ultra sonic scanning unit
   - 1 Oven
   - 1 Lamp, ultraviolet
   - 1 Sterilizor, instrument
   - 1 Sterilizor, general purpose
   - 2 Respirator, portable
   - 2 Respirator, treatment
   - 1 Diathermy apparatus
   - 1 Audiometer
   - 1 Dialysis machine

8. *Laboratory Test Instruments*
   - 10 Oscilloscope
   - 1 Oscilloscope, dual beam, storage
   - 20 Multimeter, high input impedance
   - 10 Power supply, low voltage
   - 10 Power supply, high voltage
   - 2 Digital VOM
   - 10 Generator, audio
   - 10 Generator, function
   - 2 Test set, microamperes, electrical safety
   - 1 Test instrument conductivity megohmmeter
   - 2 volt meter, D.C. 0-300 volts, 6 ranges
   - 2 Volt meter, A.C. 0-300 volts, 6 ranges
   - 1 Ammeter, D.C. 0-5 amperes
   - 1 Ammeter, A.C. 0-5 amperes
   - 1 Millimeter, D.C. 0-15 milliamperes
   - 1 Millimeter, A.C. 0-15 milliamperes
   - 1 Portable tube tester
   - 2 Pressure gauge, 0-60 psi
   - 1 Transitor tester

9. *Tools and supplies*

1 Small power drill press
1 Small power grinder
1 Steam boiler, approximately 25# pressure, approximately 10 H.P.
1 Small air compressor
1 Notcher, sheet metal
1 Squaring shear, sheet metal
1 Punch, turrent, sheet metal
1 Band saw, 16"
4 Screwdriver, plastic handle, 3" blade
4 Screwdriver, plastic handle, 4" blade
4 Screwdriver, plastic handle, 8" blade
4 Screwdriver, jeweler's type, set of 5
4 Screwdriver, split tip
4 Screwdriver, 6" offset
4 Pliers, side cutting, 8"
4 Pliers, long nose, 6"
4 Pliers, slip joint, 9½"
4 Pliers, combination, 5½"
4 Pliers, diagonal cutting, 6"
4 Wrenches, open end set, ½" to 2"
4 Wrench, adjustable, 6"
4 Wrench, adjustable, 8"
4 Pipe wrench, 6"
4 Pipe wrench, 8"
4 Hex, wrenches, set
4 Spline wrenches, set
4 Files, assorted
4 File, round, 10"
4 File, flat, 10"
4 File, square, 10"
4 File, triangular, 8"
4 Emery cloth, fine, package
4 Sandpaper, assorted, package
4 Crocus cloth, package
4 Hammer, ball peen, 16 oz.
4 Chisel, ¾" cold
4 Hacksaw frame, adjustable, 12"
4 Hacksaw blades, package, 18 teeth, 12"
4 Hacksaw blades, package, 25 teeth, 12"
4 Knife, electrician's with locking screwdrivers blade
4 Fuse puller, pocket-type
4 Painter's sash brush, 1"
4 Oil can, straight nozzle, ½ pint
4 Friction tape, 8 oz. roll
4 Tape, plastic electrical, 60" roll
1 Flaring tool kit, heavy duty
2 Torch, propane
20 Soldering iron, 40 watts, 16 oz., 110 v. 60 cycles
4 Soldering gun, instant heat, 90 watts, 110 v. 60 cycles
4 Wire brush
4 Magnifying glass
1 Single conductor, copper, thermoplastic insulated wire-#12 ga.-22 ga., roll 250 ft.
1 Wire, copper, stranded, thermoplastic insulated, #12 ga.-22 ga. roll 250 ft.
100 Terminals, spade tongue, 14-20 ga.
100 Terminals, ring tongue, 14-20 ga.
1 Terminal kit, assorted
1 Wire solder, 50/50 1 spool (5 lbs.)
1 Wire solder, resin core 50/50, 1 spool (5 lbs.)
1 Soldering flux, paste-resin, 1 container (5 lbs.)
– Assorted solvents, lubricants and cleaners
4 Punch, pin
4 Punch, starting
4 Punch, center

For further information on BMET equipment, write to:

BMET Clearinghouse Coordinator
Technical Education Research Centers
44 Brattle Street
Cambridge, MA 02138

# APPENDIX H

## RELATED JOURNALS/PERIODICALS

AAMI NEWS
Association for the Advancement of Medical Instrumentation
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209
Issue Rate: Bi-monthly.

BMET NEWS
Association for the Advancement of Medical Instrumentation
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209

BIOMEDICAL ELECTRONICS
Girard Associates, Inc.
Box 455
Mount Arlington, NJ 07856
Subscription Rate: $60.
Issue Rate: Semi-monthly.

BIOMEDICAL ENGINEERING
Plenum Publishing Company
227 West 17th Street
New York, NY 10001
Subscription Rate: $95.
Issue Rate: Bi-monthly.

BIOMEDICAL SAFETY AND STANDARDS
Quest Publishing Company
P.O. Box 4141
Diamond Bar, CA 91765
Subscription Rate: $48.
Issue Rate: Monthly.

BIOMEDICAL TECHNOLOGY INFORMATION SERVICE
Quest Publishing Company
P.O. Box 4141
Diamond Bar, CA 91765
Subscription Rate: $72.
Issue Rate: Monthly.

CLINICAL ENGINEERING NEWS
Association for the Advancement of Medical Instrumentation
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209
Subscription Rate: $25.
Issue Rate: Bi-monthly.

HEWLETT-PACKARD JOURNAL
Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, CA 94304
Subscription Rate: No charge.
Issue Rate: Monthly.

IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING
The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, NY 10017
Subscription Rate: $42.
Issue Rate: Bi-monthly.

JOURNAL OF CLINICAL ENGINEERING
Quest Publishing Company
P.O. Box 4141
Diamond Bar, CA 91765

MEDICAL INSTRUMENTATION
Association for the Advancement of Medical Instrumentation
1901 North Ft. Myer Drive, Suite 602
Arlington, VA 22209
Issue Rate: Bi-monthly.

MEDICAL ELECTRONICS AND EQUIPMENT NEWS
Reilly Publishing Company
216 West Higgins Street
Park Ridge, IL 60068
Subscription Rate: $12.
Issue Rate: Bi-monthly.

MEDICAL ELECTRONICS
Medical Electronics Society
2994 West Liberty Avenue
Pittsburgh, PA 15216

# APPENDIX I

## AAMI STANDARDS AND TECHNICAL DOCUMENTS

**Association for the Advancement of Medical Instrumentation**

## STANDARDS AND TECHNICAL DOCUMENTS AAMI

Devices, Instruments and Systems

**DATE**

**Prepayment is required.** Discount available for quantities in excess of ten each per standard.

MAIL CHECKS TO:

AAMI
P.O. BOX 460
SPRINGFIELD VA 22150

Return one copy with your check. Make check payable to AAMI.
Your cancelled check is your receipt.

| *Standards and Technical Documents* | *Quantity* | *Price per Copy* *Member* | *Nonmember* | *Total* |
|---|---|---|---|---|
| AAMI BIER/Steam Vessel Standard (Proposed) (Ref: AAMI BSV-P 4/78) | _____ | $ 6.00 | $10.00 | $_____ |
| AAMI Draft Standard Guidelines (Ref: AAMI DSDG 11/75) | _____ | 4.00 | 5.00 | _____ |
| AAMI E-O Sterilization Standard (Proposed) (Ref: AAMI EOS-P 11/77) | _____ | 6.00 | 10.00 | _____ |
| AAMI Implantable Pacemaker Standard (Proposed) (Ref: AAMI IP-P 10/75) | _____ | 16.00 | 24.00 | _____ |
| AAMI Process Control Guidelines for Radiation Sterilization of Medical Devices (Proposed) (Ref: AAMI RS-P 4/78) | _____ | 6.00 | 10.00 | _____ |
| AAMI Standards Manual (ANSI Accredited): How to Develop, Approve and Promulgate Voluntary Consensus Standards | _____ | (postage & handling charge only) | | _____ |
| American National Standard—Safe Current Limits for Electromedical Apparatus (Ref: ANSI/AAMI SCL 12/78) | _____ | 8.00 | 12.00 | _____ |
| Ethylene Oxide Sterilization—A Guide for Hospital Personnel (Ref: AAMI EOSG 7/76) | _____ | (No charge for one copy) | | |
| Good Hospital Practice: Steam Sterilization and Sterility Assurance (Proposed) | _____ | 8.00 | 13.00 | _____ |
| Good Manufacturing Practices (GMP) Manual: How to Develop Your GMP/QC Manual | _____ | 25.00 | 30.00 | _____ |
| Medical Device Amendments of 1976: Summary | _____ | (postage & handling charge only) | | _____ |

Subtotal $_____

Plus postage and handling charge on all orders $ 2.00

VA residents add 4% sales tax _____

TOTAL REMITTANCE $_____

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